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GRAPHIC MATERIALS TO SUPPORT BIOPHYSICAL QUANTITATIVE ENVIRONME--ETC(U)
MAR 79 W D GORAN, R E RIGGINS

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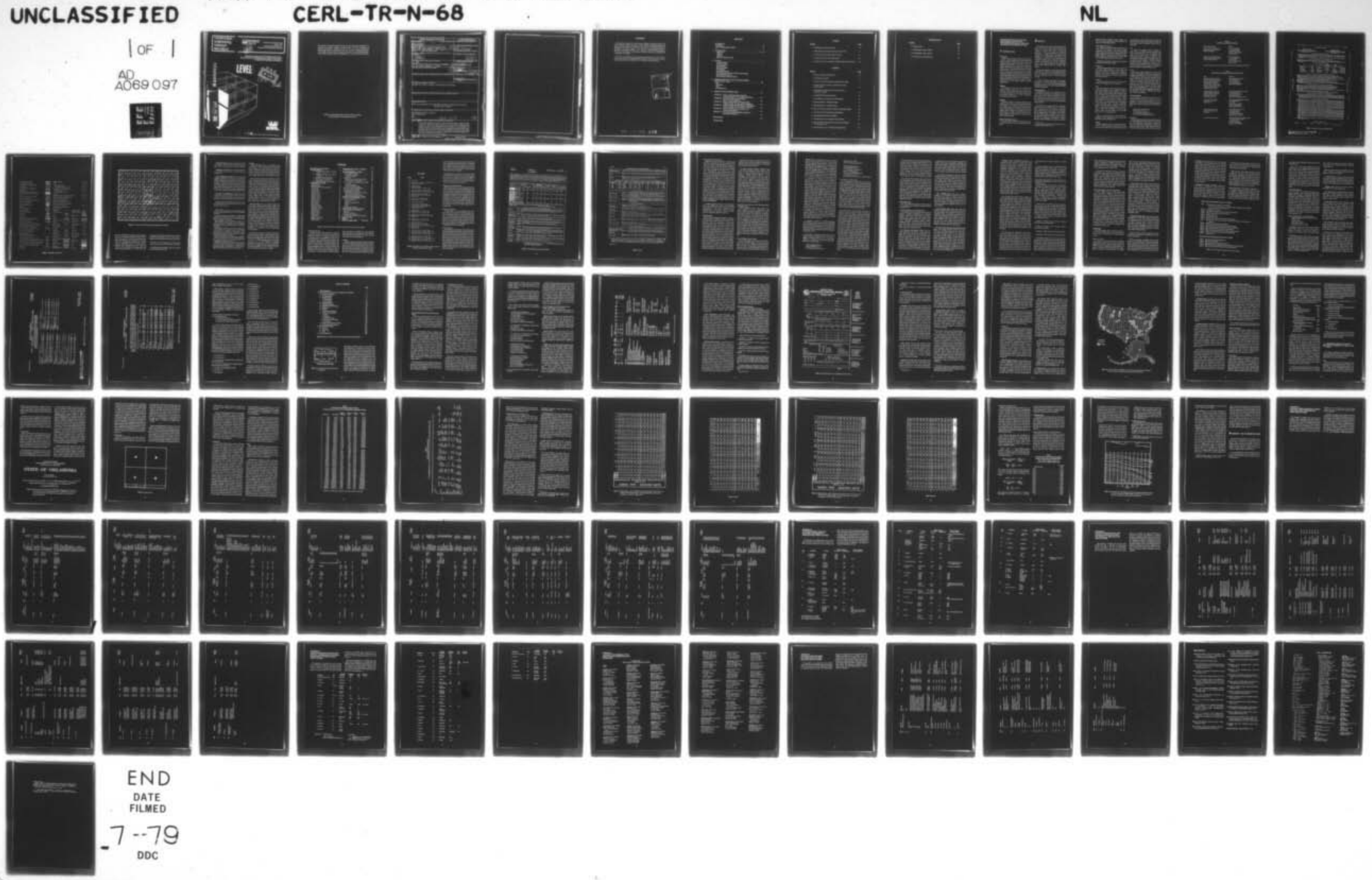

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TECHNICAL REPORT N-68
March 1979
Analytical Model System for
Prediction of Environmental Impacts

GRAPHIC MATERIALS TO SUPPORT BIOPHYSICAL QUANTITATIVE ENVIRONMENTAL IMPACT ANALYSIS— SOURCES OF EXISTING MATERIALS

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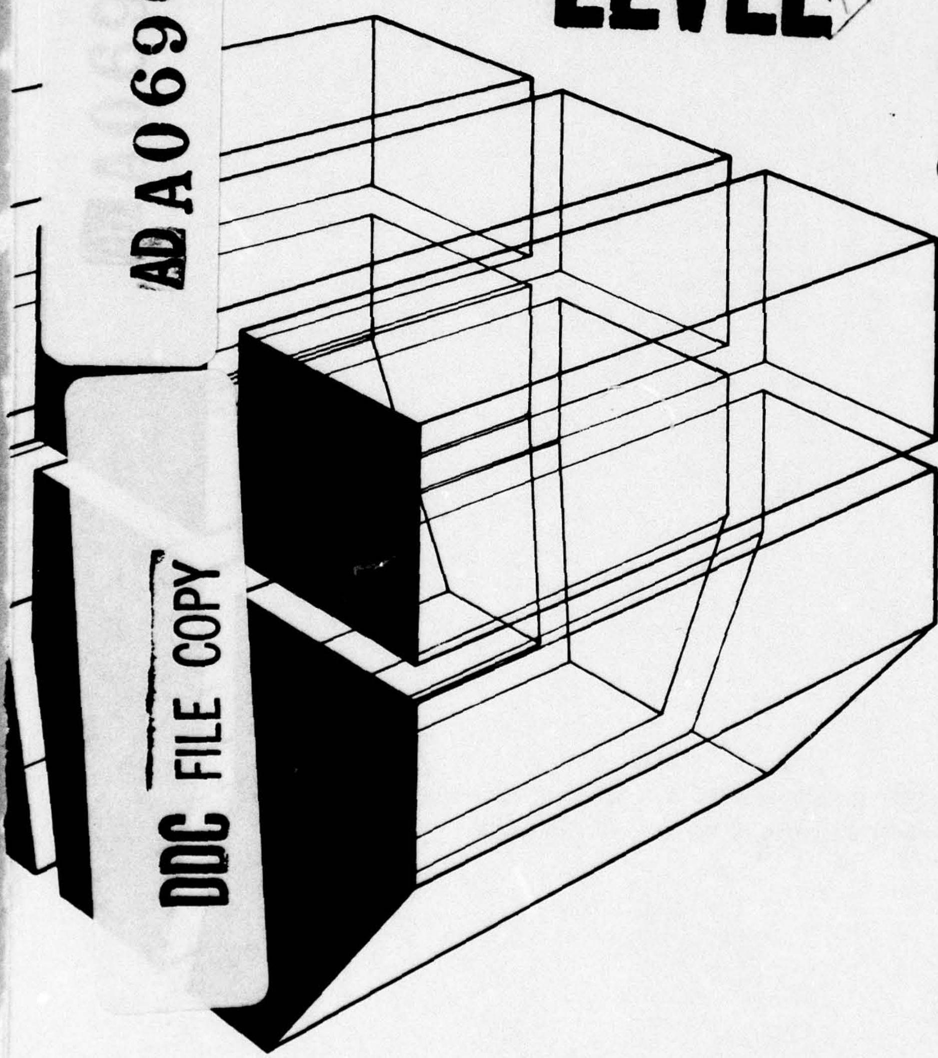

by
W. D. Goran
R. E. Riggins

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ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report identifies and describes resource materials (maps and imagery) currently available for environmental impact analysis on U.S. Army military installations. Only materials that relate to the biophysical and land use elements of the environment are considered. The report describes procedures for obtaining these materials and lists specific materials relevant to major U.S. Army military installations. This report also provides some tables, formulas, and procedures for quantitatively analyzing these graphical representations of environmental information.

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FOREWORD

This study was conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities"; Task 01, "Environmental Quality Management for Military Facilities"; Work Unit 006, "Analytical Model System for Prediction of Environmental Impacts." Dr. L. Schindler was the OCE Technical Monitor. The efforts of Edi Hogsett of the University of Illinois in preparation of the appendices are gratefully acknowledged.

This study was conducted by the Environmental Division (Dr. R. K. Jain, Chief), of the U.S. Army Construction Engineering Research Laboratory (CERL). COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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GRAPHIC MATERIALS TO SUPPORT BIOPHYSICAL QUANTITATIVE ENVIRONMENTAL IMPACT ANALYSIS—SOURCES OF EXISTING MATERIALS

1 INTRODUCTION

Background

Graphic materials provide environmental information that cannot be obtained from other sources, and graphic displays are often the most practical method of compiling environmental information. Until now, graphic materials have not been more widely used, largely because their total potential has not been considered as part of environmental information acquisition procedures. This report is the first of a series devoted to creating more widespread use of graphic materials during environmental impact analysis. Future reports will describe adaptations of graphic materials to Army environmental needs and the development of special-purpose graphic materials to support and supplement air and water quality models for impact quantification.

Objective

The objective of this report is to describe the sources of graphic material that may be used in environmental impact analysis. The report is intended for use by Army planners and decision-makers who require environmental information to perform quantitative environmental impact analysis.

Approach

Information needs for analytical models were investigated, and existing sources of graphic information were identified and evaluated. Selected information from existing sources was obtained to determine the currency and usefulness of the information for Army military facilities. Listings were compiled of sources of useful graphic materials. Graphic information was further analyzed to determine which formats are most useful for impact analysis.

Mode of Technology Transfer

This report, when combined with future reports of this series, will become a new DA pamphlet in the 200 series.

2 SOURCES

The introduction of the book, *Environmental Analysis,*[1] states that "Increased concern with the environment in virtually every sector of society has produced a surge in the demand for environmental information . . . (such as) information on slope, soil, vegetation, and drainage which is not usually readily available in a communicable information format. Nevertheless, the *sources* of such information are available to virtually everyone. These sources represent processed environmental data; namely, topographic contour maps, aerial photographs, soil maps, hydrographic maps, drainage data, and remotely sensed imagery."

This chapter identifies source materials available nationwide that depict major biophysical characteristics of the landscape. The sources identified are produced at a large scale (1 inch to 1 mile, 1 to 63,360, or larger).

As much as possible, maps, reports, and agencies that relate to U.S. Army installations are identified. Appendices A, B, C, D, and F reference specific maps and reports that relate to the sites of major FORSCOM /TRADOC installations.

Topographic Maps

Topographic maps show the configuration of the earth's surface and indicate (by shading, contour lines, spot elevations, and/or figurative representations of the land surface) relief as well as the positions of natural and man-made features. These maps are the primary source materials for many environmental planning and analysis purposes.

Essentially only two agencies produce topographic contour maps in the United States on a nationwide basis: the Department of the Interior's Geological Survey (USGS) and the Department of the Defense's Defense Mapping Agency Topographic Center (DMA-TC). The DMATC maps are discussed in the section of this Chapter entitled *Army-Unique Sources,* because large-scale U.S. mapping by this agency is confined mostly to military installations. In addition, a few state

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[1] William Marsh, *Environmental Analysis for Land Use and Site Planning* (McGraw-Hill, 1978), p 2.

agencies produce topographic maps, usually on a county-format basis, which are briefly discussed in the subsection *General Highway Maps.*

USGS Ordering Information

The following ordering information is relevant to all USGS products discussed in this report, including topographic maps, geologic and hydrologic maps, remote sensing products, and the National Atlas. The regional National Cartographic Information Center (NCIC) Offices may have information on other USGS and non-USGS mapping programs and materials.

Published maps should be ordered from the Branch of Distribution as indicated in Table 1.

Description

USGS Topographic Maps are multi-color maps with the terrain surface indicated by contour lines and bounded by parallels of latitude and meridians of longitude. They include information of drainage, vegetation, roads, urban areas, political boundaries, and other cultural features.

Coverage

All of the United States, the U.S. territories, and Antarctica are mapped at one or more scales.

Scales

More than 80 percent of the United States and U.S. territories are mapped at either 1:24,000, 1:62,500, or both of these scales. In some instances (i.e., Puerto Rico, Alaska, and Antarctica), slightly different scales are used. USGS also has mapped the entire United States at several smaller scales, including 1:250,000 and 1:1,000,000. All of the above maps are in quadrangle format, and each scale size is called a series. Selected areas of the United States are also mapped in a county boundaries format rather than a quadrangle format, with scale varying according to county size. USGS is now placing major emphasis on "metric" series, 1:25,000 and 1:100,000. A prototype map, "Saranac Lake," has been published at the 1:25,000 scale on a 7 1/2 X 15-minute format.

Figure 1 is excerpted from a 1972 USGS sheet, *Topographic Map Information Symbols,* and summarizes the major quadrangle series.

Updating

USGS topographic maps are periodically updated both from aerial photographs and field checks. Updating activities depend on cooperating agencies' needs and priorities. On map reprints, photo revisions are indicated with a purple tint, and maps are printed with both original date of publication and date of the revision(s).

Aids

A booklet ("Topographic Maps") published in April 1969 contains information on topographic map scales, mapping procedures, accuracy standards, and a symbols key. Another sheet, "Topographic Map Information Symbols," published by USGS in 1972, also provides basic information, topographic maps, and a symbols key (see Figure 2). "Tools for Planning Topographic Maps," published by USGS in 1971, discusses uses for topographic maps. All three publications are available at no charge from the Branch of Distributions offices as listed in Tables 1 and 2.

Indexes

Index maps are also available free of charge from the Branch of Distributions. Indexes for each state list available maps published at both the 1:24,000 and the 1:62,500 scales; provide information on small-scale and special maps; list state reference libraries and map dealers; and indicate ordering procedures. Figure 3, "Excerpt of the USGS Topographic Index, Kansas," illustrates how the two scales are indicated on one index sheet. Status index maps for the entire United States are also available free for each of the intermediate and small-scale USGS topographic series, including 1:100,000, 1:250,000, 1:1,000,000, and Intermediate Scale County Mapping.

Soil Survey Reports

Soil maps show the different kinds of soil on a landscape and their relation to other features on the landscape. The major producing agency is the U.S. Department of Agriculture's Soil Conservation Service (SCS), which can be contacted at the following address:

Administrator for Soil Survey
Soil Conservation Service
U.S. Department of Agriculture
P.O. Box 2890, Washington DC 20013

Description

SCS publishes soil maps as soil survey reports which are bound publications that include both maps and text. The Department of Agriculture, in cooperation with other Federal and state agencies, has been publishing soil surveys since 1899. During this period, there have been significant advances in soil sciences,

Table 1
USGS Branch of Distribution Offices

Maps of Following Areas	Address
Areas *east* of the Mississippi River, including Minnesota, Puerto Rico, and the Virgin Islands	Branch of Distribution U.S. Geological Survey 1200 South Eads Street Arlington, Virginia 22022 (703) 557-2781
Areas *west* of the Mississippi River, including Alaska, Hawaii, Louisiana, Guam, and American Samoa.	Branch of Distribution U.S. Geological Survey P.O. Box 25286 Denver, Colorado 80225 (303) 234-3832

Advance materials and feature separates should be ordered from the addresses listed in Table 2.

Table 2
USGS National Cartographic Information Center Offices

Area	Addresses
Alabama, Connecticut, Delaware, Florida, Georgia, Indiana, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, *Virginia and West Virginia*	Eastern Mapping Center–NCIC U.S. Geological Survey 536 National Center Reston, Virginia 22092 Telephone (703) 860-6393
Arkansas, Illinois, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin	Mid-Continent Mapping Center–NCIC U.S. Geological Survey 1400 Independence Road Rolla, Missouri 65401 Telephone (314) 364-3680, Ext 107
Alaska, Colorado, Montana, New Mexico, Texas, Utah and Wyoming	Rocky Mountain Mapping Center–NCIC U.S. Geological Survey Box 25046 Federal Center, Building 25 Denver, Colorado 80225 Telephone (303) 234-2351
Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington	Western Mapping Center–NCIC U.S. Geological Survey 345 Midlefield Road Menlo Park, California 94025 Telephone (415) 323-2427
Any area of the United States	National Cartographic Information Center U.S. Geological Survey (NCIC) 507 National Center Reston, Virginia 22092 Telephone (703) 860-6045

MILE SCALE 1:62 500

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TOPOGRAPHIC
MAP INFORMATION AND SYMBOLS
SEPTEMBER 1972

QUADRANGLE MAPS AND SERIES

Quadrangle maps cover four-sided areas bounded by parallels of latitude and meridians of longitude. **Quadrangle size** is given in minutes or degrees. The usual dimensions of quadrangles are: 7.5 by 7.5 minutes, 15 by 15 minutes, and 1 degree by 2 or 3 degrees.

Map series are groups of maps that conform to established specifications for size, scale, content, and other elements.

MAP SCALE DEPENDS ON QUADRANGLE SIZE

Map scale is the relationship between distance on a map and the corresponding distance on the ground.

Map scale is expressed as a numerical ratio or shown graphically by bar scales marked in feet, miles, and kilometers.

NATIONAL TOPOGRAPHIC MAPS

Series	Scale	1 inch represents	Standard quadrangle size (latitude-longitude)	Quadrangle area (square miles)	Price
7½-minute	1:24,000	2,000 feet	7½×7½ min.	49 to 70	~~$0.75~~ 1.25
Puerto Rico 7½-minute	1:20,000	about 1,667 feet	7½×7½ min.	71	~~[illegible]~~ 1.25
15-minute	1:62,500	nearly 1 mile	15×15 min.	197 to 282	~~[illegible]~~ 1.25
Alaska 1:63,360	1:63,360	1 mile	15×20 to 36 min.	207 to 281	~~[illegible]~~ 1.00
U. S. 1:250,000	1:250,000	nearly 4 miles	1° × 2° or 3°	4,580 to 8,669	~~1.00~~ 2.00
U. S. 1:1,000,000	1:1,000,000	nearly 16 miles	4° × 6°	73,734 to 102,759	~~1.00~~ 2.00
Antarctica 1:250,000	1:250,000	nearly 4 miles	1° × 3° to 15°	4,089 to 8,336	~~[illegible]~~ 1.25
Antarctica 1:500,000	1:500,000	nearly 8 miles	2° × 7½°	28,174 to 30,462	~~.75~~ 1.25

CONTOUR LINES SHOW LAND SHAPES AND ELEVATION

The shape of the land, portrayed by contours, is the distinctive characteristic of topographic maps.

Contours are imaginary lines following the ground surface at a constant elevation above or below sea level.

Contour interval is the elevation difference represented by adjacent contour lines on maps.

Contour intervals depend on ground slope and map scale; they vary from 5 to 1,000 feet. Small contour intervals are used for flat areas; larger intervals are used for mountainous terrain.

Supplementary dotted contours, at less than the regular interval, are used in selected flat areas.

Index contours are heavier than others and most have elevation figures.

Relief shading, an overprint giving a three-dimensional impression, is used on selected maps.

Orthophotomaps, which depict terrain and other map features by color-enhanced photographic images, are available for selected areas.

COLORS DISTINGUISH KINDS OF MAP FEATURES

Black is used for manmade or cultural features, such as roads, buildings, names, and boundaries.

Blue is used for water or hydrographic features, such as lakes, rivers, canals, glaciers, and swamps.

Brown is used for relief or hypsographic features—land shapes portrayed by contour lines.

Green is used for woodland cover, with patterns to show scrub, vineyards, or orchards.

Red emphasizes important roads and is used to show public land subdivision lines, land grants, and fence and field lines.

Red tint indicates urban areas, in which only landmark buildings are shown.

Purple is used to show office revision from aerial photographs. The changes are not field checked.

INDEXES SHOW PUBLISHED TOPOGRAPHIC MAPS

Indexes for each State, Puerto Rico and the Virgin Islands of the United States, Guam, American Samoa, and Antarctica show available published maps. Index maps show quadrangle location, name, and survey date. Listed also are special maps and sheets, with prices, map dealers, Federal distribution centers, and map reference libraries, and instructions for ordering maps. Indexes and a booklet describing topographic maps are available free on request.

HOW MAPS CAN BE OBTAINED

Mail orders for maps of areas east of the Mississippi River, including Puerto Rico, the Virgin Islands of the United States, and Antarctica should be ordered from the U. S. Geological Survey Distribution Section, 1200 South Eads Street, Arlington, Virginia 22202. Maps of areas west of the Mississippi River, including Alaska, Hawaii, Louisiana, Minnesota, American Samoa, and Guam should be ordered from the Distribution Section, Federal Center, Denver, Colorado 80225. A single order combining both eastern and western maps may be placed with either office. Residents of Alaska may order Alaska maps or an index for Alaska from the Distribution Section, 310 First Avenue, Fairbanks, Alaska 99701. Order by map name, State, and series. Maps without woodland overprint are available on request. On an order amounting to $300 or more at the list price, a 30-percent discount is allowed. No other discount is applicable. Prepayment is required and must accompany each order. Payment may be made by money order or check payable to the U. S. Geological Survey, or cash (the exact amount) at sender's risk. Your ZIP code is required.

Sales counters are maintained in the following U. S. Geological Survey offices, where maps of the area may be purchased in person: 1200 South Eads Street, Arlington, Va.; Room 1028, General Services Administration Building, 18th & F Streets NW., Washington, D. C.; 1109 North Highland Street, Arlington, Va.; 900 Pine Street, Rolla, Mo.; 345 Middlefield Road, Menlo Park, Calif.; 7638 Federal Building, 300 North Los Angeles Street, Los Angeles, Calif.; 504 Custom House, 555 Battery Street, San Francisco, Calif.; Building 41, Federal Center, Denver, Colo.; 1012 Federal Building, 1961 Stout Street, Denver, Colo.; Room 1-C 45, 1100 Commerce Street, Dallas, Texas; 8102 Federal Building, 125 South State Street, Salt Lake City, Utah; 678 U. S. Court House, West 920 Riverside Avenue, Spokane, Wash.; 108 Skyline Building, 508 Second Avenue, Anchorage, Alaska; 441 Federal Building, 709 West Ninth Street, Juneau, Alaska; and 310 First Avenue, Fairbanks, Alaska.

Commercial dealers sell U. S. Geological Survey maps at their own prices. Names and addresses of dealers are listed in each State index.

MILE SCALE 1:24 000

FOOT SCALE 1:24 000

FOOT SCALE 1:62 500

Figure 1. Summary of major quadrangle series.

Figure 2. Topographic map symbols.

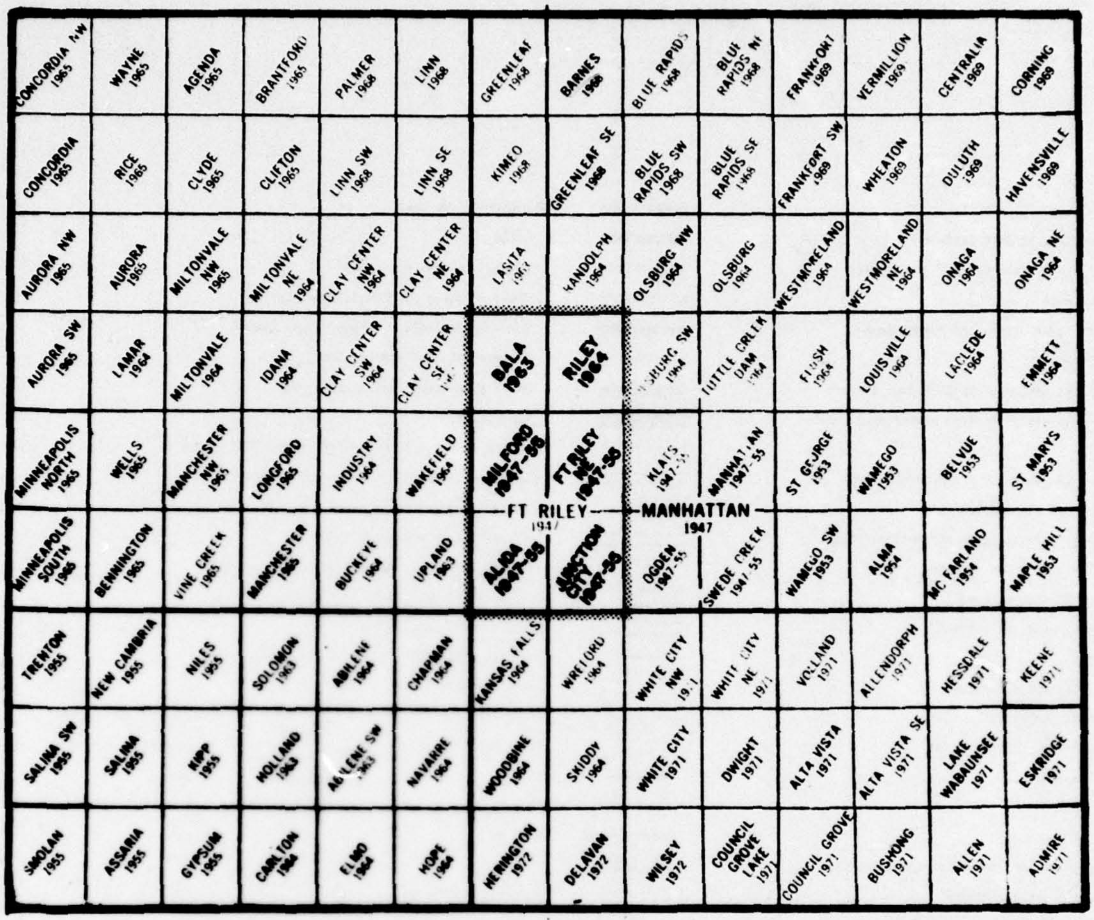

Figure 3. Excerpt from the USGS large-scale topographic series, Kansas.

and these advances have resulted in several changes in the type of information presented in soil surveys as well as the manner in which the information is presented. All SCS surveys now comply with a nationwide system of soil classification nomenclature, interpretation, and publication. Some of the older surveys, especially those published before 1957, while still useful, are less standardized in mapping units, and many need updating. Figure 4 is a copy of the Contents page of the *Soil Survey of Riley County and Part of Geary County, Kansas,* June 1975. This survey is published in the standard SCS format described below:

The Text. The text begins with a brief description of the survey area and the current land use practices.

How This Survey Was Made. This section explains the survey's preparation and use.

General Soil Map. This section explains the formation analysis of soil associations identified within the study area to accompany the "General Soil Map."*

Description of the Soils. This section describes the series within the survey area and the phases within each of these series.

Use and Management of Soils. This section provides capability ratings of each soil unit by a national capability ranking system having eight classes and various subclasses.[2] This system is oriented to crop production and also to woodland and wildlife habitat interpretation. Agricultural use of soil has traditionally been the major focus in producing surveys, but in recent decades SCS's focus has expanded to include interpretations for other uses, such as recreation and engineering use.

Formation and Classification of Soils. This section explains how each soil in the survey area was formed, and provides general information on soil science, technical terms, and morphological and formation theory.

General Nature of the Survey Area. This section provides land use, climatic, and natural resource information on the survey area.

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[2]SCS's *Agricultural Handbook #210 (Land Capability Classification)* provides detailed information on this soil classification system.

*To read soil maps, it is first necessary to understand soil classifications. The following definitions are adopted from Brady, *The Nature and Properties of Soils* (MacMillan Publishing Co., 1974), pp 617, 618, and 613.

Soil Associations. A group of defined and named taxonomic soil units (series) occurring together in an individual characteristic pattern over a geographic region or a landscape. Associations are named for their major series, such as Eudora-Haynie-Sarpy.

Soil Complex. A mapping unit in a soil survey map indicating an area where two or more soil series are so intermingled or so small that it is impractical to separate them. A more intimate mixing of soil units than an association. As with association, soil complexes are named from their dominant soils, such as Benfield-Florence Complex.

Soil Series. The basic unit of soil classification consisting of soils that are essentially alike in all major profile characteristics. Soil series are names for a town or geographic feature near the place where the soil was first observed.

Soil Phase. A subdivision of a soil series having characteristics that affect the use and management of the soil but which do not vary enough to differentiate as a separate series. A variation in a property or characteristic of a soil series such as degree of slope, degree of erosion, and content of stones.

The Maps

General Soil Map. These are small-scale, multicolored maps of the entire survey area which delineate soil associations. The maps illustrate the broad geographic relationships among soils in the survey area. General soil maps are frequently published separately for large areas such as states, and sometimes for counties or regions that have no soil series maps available.

Scales of general soil maps vary with the size of the survey area and the page size in which the map is printed. The *Soil Survey of Riley County and Part of Geary County, Kansas* includes 611 sq mi (985-km^2) in Riley County and 9000 acres (2644 hectares) in Geary. The map is a two-page foldout with a scale of 1:253,440. *The Soil Survey of Calloway and Marshall Counties, Kentucky* (December 1973), (Fort Campbell) provides a map (scale of 1 to 126,720) of a 687 sq mi (1787-km^2) area. *The Soil Survey of Jennings County, Indiana* (March 1976) (Jefferson Proving Ground) provides a map of a 377-sq mi (981-km^2) area. The format is a two-page foldout similar to the Riley County survey, and the scale is 1:126,720.

Soil Series Maps. These are detailed, large scale maps, usually consisting of several sheets, a legend, and an index map. In recent years (with occasional exceptions), these maps have used aerial photomosaics (orthophoto maps) as a base. The mapped information usually consists of irregular polygons identified with a symbol relating to a particular soil in the legend. Each soil mapping unit is identified by series name (Irwin), by textural classification (Irwin *silty clay loam*), and by phase, if any phases occur (Irwin silty clay loam, *4 to 8 percent slope, eroded*). Figure 5 provides an example of the Soil Legend for *Riley County and Part of Geary County, Kansas.* Some natural and cultural information, such as roads, towns, cemeteries, and drainageways, is overprinted onto the photomosaics for easy reference.

Soil series map scales vary according to the survey area size, format or page size, and the number of map sheets. For example, *Riley County and Part of Geary County* have 40 map sheets, each 14.25 X 9.25 in. with a scale of 1 to 24,000. *Jennings County* has 57 sheets at a scale of 1 to 15,840. *Calloway and Marshall Counties* have 89 sheets at a scale of 1 to 15,840. The *Soil Survey of Calhoun County, Alabama* (September 1961) (Fort McClellan), an area of 610 sq mi (1587-km^2), has 38 sheets at a scale of 1 to 20,000.

Contents

I

Figure 4. Contents, *Soil Survey of Riley County and Part of Geary County, Kansas.*

Cooperating Agencies

Generally the Soil Conservation Service cooperates with another Federal or state agency to produce and publish a soil survey. For example, the Calhoun County, Alabama, Survey was published by SCS, the Alabama Department of Agriculture and Industries, and the Alabama Agricultural Experiment Station. The Jennings County, Indiana, survey was published by the SCS in cooperation with the Purdue University Agricultural Experiment Station, while the Calloway and Marshall County Survey was published by SCS in cooperation with the Kentucky Agricultural Experiment Station. A limited number of soil surveys have been conducted and published by other agencies. Generally, the state conservationist or the local SCS office will still be the best point of contact to obtain information about such publications.

Coverage

Extensive field and laboratory analysis is required for soil series mapping. Although this process has been carried out in the United States since 1899, it is now being conducted in some areas of the country for the first time. Producing general soil maps also requires field work, but on a much less detailed level. Thus, most of the United States has been mapped by associa-

SOIL LEGEND

SYMBOL	NAME
Ad	Alluvial land
Bf	Benfield-Florence complex, 5 to 20 percent slopes
Bk	Breaks-Alluvial land complex
Ca	Carr-Sarpy complex
Ch	Chase silty clay loam
Cs	Clime-Sogn complex, 5 to 20 percent slopes
Dr	Dwight-Irwin complex, 1 to 4 percent slopes
Dw	Dwight-Irwin complex, 1 to 4 percent slopes, eroded
Em	Elmont silt loam, 3 to 8 percent slopes
En	Elmont-Clime complex, 5 to 15 percent slopes
Eu	Eudora silt loam
Ga	Geary silt loam, 1 to 4 percent slopes
Ge	Geary silt loam, 4 to 8 percent slopes
Ha	Haynie very fine sandy loam
Ic	Irwin silty clay loam, 4 to 8 percent slopes
Id	Irwin silty clay loam, 4 to 8 percent slopes, eroded
Ie	Ivan silty clay loam, 1 to 3 percent slopes
Iv	Ivan and Kennebec silt loams
Ka	Kahola silt loam
Ke	Kenesaw silt loam, 2 to 6 percent slopes
Kf	Kenesaw silt loam, 6 to 10 percent slopes
Ma	Mayberry clay loam, 2 to 6 percent slopes
Mb	Mayberry clay loam, 2 to 6 percent slopes, eroded
Mu	Muir silt loam
Rd	Reading silt loam, 0 to 1 percent slopes
Re	Reading silt loam, 1 to 3 percent slopes
Sa	Sarpy loamy fine sand
Sm	Smolan silt loam, 1 to 4 percent slopes
Sn	Smolan silt loam, 4 to 8 percent slopes
So	Smolan silty clay loam, 4 to 8 percent slopes, eroded
St	Stony steep land
Su	Sutphen silty clay
Ts	Tully silty clay loam, 1 to 4 percent slopes
Tt	Tully silty clay loam, 1 to 4 percent slopes, eroded
Tu	Tully silty clay loam, 4 to 8 percent slopes
Tv	Tully silty clay loam, 4 to 8 percent slopes, eroded
Wm	Wymore silty clay loam, 0 to 1 percent slopes
Wn	Wymore silty clay loam, 1 to 4 percent slopes
Wo	Wymore silty clay loam, 1 to 4 percent slopes, eroded
Wr	Wymore silty clay loam, 4 to 8 percent slopes
Ws	Wymore silty clay loam, 4 to 8 percent slopes, eroded

Figure 5. Soil Legend for *Soil Maps of Riley County and Part of Geary County, Kansas.*

tion, though only at the state level in some areas. Only three states (Maryland, Rhode Island, and Delaware) have published soil surveys available for all counties. Since farmers and farm-related agencies have been the major users of soil surveys, areas of intensive farming have been the first to be mapped.

Most soil surveys are done on a one- or two-county basis. Some soil surveys are done for non-county units, i.e., *Soil Survey of Harford County Area, Maryland* (August 1975) (Aberdeen Proving Ground). When a survey covers only a part of one or more counties, the word "area" is generally used in the title.

Special Army Use Considerations

Military installations may encounter particular problems in using soil surveys, since installations are often located in more than one county, and mapping may not yet have been completed for all of them. Even if mapping has been done in all pertinent counties, there could still be problems because of differences in scale; in addition, if the surveys were published at widely different dates, some of the mapping nomenclature and interpretation techniques may differ. Furthermore, some counties, e.g., Jennings County, Indiana (Jefferson Proving Ground) omit military lands from the mapping areas.

Cooperative Programs

In most states, a current published survey is still not available for all counties; thus, SCS mapping priorities are generally directed to unmapped areas, rather than to revising previously mapped areas. The SCS maps areas in cooperative programs, whereby SCS pays half the cost, and the local unit (usually the county) pays the other half. The program varies from state to state, and the initiation of a mapping project, as well as updating, depends on the agreement.

Other Resources

Soil interpretation sheets have been produced by SCS for each soil series identified in the United States. The sheets describe the soil characteristics, and provide much the same interpretation information as is available in the soil survey for each particular soil series. (See Figure 6 for an example of the soil interpretation sheet.) Furthermore, state conservationists and some county agricultural extension agents have statistics for each soil series, including K Factor, T Factor, Hydrologic Soil Group, and other quantitative values needed to predict or estimate soil loss, infiltration, and other soil properties.

Map Symbols
Illinois - 14

AVA
Soil Series

MLRA 114 & 115 Date REV 1/72

SOIL INTERPRETATIONS

BRIEF SOIL DESCRIPTION : The Ava series consists of moderately well drained soils that have 2 to 18 percent slopes on uplands. They have a dark grayish brown silt loam surface layer and a yellowish brown silt loam subsurface layer. The subsoil is a strong brown light silty clay loam to a depth of about 26 inches. Below this the subsoil contains a fragipan that is dense, firm, yellowish brown silt loam to light silty clay loam mottled with gray or dark brown. The underlying material is light brownish gray silt loam or loam mottled with yellowish brown. Ava soils have a low organic matter content, slow permeability in the subsoil, and a moderate to high available water capacity. Surface runoff is medium to rapid.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES - Based on test data from Edwards County, Illinois

General Soil Profile	Classification			% of material passing sieve			Permeability inches per hour	Available water capacity in./in.	Soil reaction pH	Shrink-swell potential
	USDA Texture	Unified	AASHO	No. 4 5.0 mm	No. 10 2.0 mm	No. 200 0.074 mm				
	Surface layer Silt loam 0 to 9 inches	ML or CL	A-4 or A-6	100	100	95-100	0.63-2.00	.20-.25	4.5-6.0	Low
	Upper subsoil Light silty clay loam 9 to 26 inches	CL	A-6	100	100	95-100	0.63-2.00	.19-.21	4.5-5.5	Moderate
	Lower subsoil Silt loam to light silty clay loam 26 to 48 inches	CL	A-6	100	95-100	85-100	0.06-0.20	.10-.16	4.5-5.5	Moderate
	Underlying material Silt loam or loam 48 to 60 inches	ML	A-6 or A-4	100	90-100	65-90	0.20-0.63	.14-.18	5.1-6.0	Low

Depth to Water Table: May perch temporarily at 26 inches below the surface in the spring.
Hydrologic Group: C
Depth to bedrock: Greater than 6 feet.

SUITABILITY AND FEATURES AFFECTING SOIL AS RESOURCE MATERIAL	
Topsoil	FAIR: Silt loam surface layer less than 9 inches thick; usually less than 1 percent organic matter content; where surface layer is removed the remaining soil is heavy silt loam or light silty clay loam, strongly acid to very strongly acid, and difficult to vegetate.
Sand and gravel	Not suitable.
Road fill for highway subgrade	POOR: Fair to poor stability and compaction characteristics; plastic index of subsoil material ranges from 12 to 19; moderate shrink-swell potential in the subsoil.

DEGREE OF LIMITATIONS AND SOIL FEATURES AFFECTING SELECTED USES 1/	
Highway and street location	MODERATE on 2 to 12 percent slopes; fair stability; exposed embankments highly erodible; subject to frost heave. SEVERE on 12 to 18 percent slopes; requires more cutting and filling; severe erosion hazard.
Foundations for low buildings	MODERATE on 2 to 12 percent slopes - subsoil has medium to high compressibility and a moderate shrink-swell potential. SEVERE on slopes exceeding 12 percent - severe erosion hazard; hillside slippage hazard.
Pond reservoir areas	SLIGHT
Dams, dikes and embankments	MODERATE: Fair to poor stability and compaction; medium to high compressibility; low to moderate permeability when compacted; fair to poor resistance to piping.
Waterways	MODERATE on 2 to 12 percent slopes.) Exposed subsoil erodes easily, is strongly acid or very strongly SEVERE on 12 to 18 percent slopes.) acid, and low in fertility; difficult to establish good sod; seepy areas on hillsides.
Drainage	Natural drainage is usually adequate. Seepy areas on hillsides in the spring.
Terraces and diversions	MODERATE on 2 to 12 percent slopes.) Exposed subsoil erodes easily, is strongly acid or very strongly SEVERE on 12 to 18 percent slopes.) acid, and low in fertility.
Irrigation	MODERATE on 2 to 12 percent slopes; moderate intake rate; slow permeability; moderate to high available water capacity; subject to runoff and erosion. SEVERE on 12 to 18 percent slopes - severe erosion hazard and rapid runoff.
Corrosion of concrete	SEVERE: High corrosion potential; strongly acid to very strongly acid subsoil.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE in cooperation with
ILLINOIS AGRICULTURAL EXPERIMENT STATION

National Cooperative Soil Survey - USA

Figure 6. Example SCS soil interpretation sheet.

INTERPRETATIONS FOR CROPLAND, PASTURE, AND WOODLAND

Cropland - general and specialty farm crops	Suited to the commonly grown crops; slopes steeper than 12 percent are seldom used for row crops; all slopes require erosion control practices; soil loss is critical on slopes exceeding 7 percent.
Pasture	Well suited to a wide range of adapted grasses and legumes where properly limed and fertilized.
Woodland	Species to favor in existing stand: White oak, Red oak, Black walnut, Tulip poplar. Suitable species to plant: Tulip poplar, Ash, White pine, Shortleaf pine. Site index range: Upland oak - 75 to 85.

PRINCIPAL MAP UNITS, CAPABILITY, AND YIELD PREDICTIONS - yields based on a high level of management

Principal Soil Map Units	Slope Range	Erosion Condition	Capability	Soil Loss K	Soil Loss T	Corn (bu)	Soybeans (bu)	Wheat (bu)	Oats (bu)	Legume-Grass Hay (tons)	Pasture (AUD)
14B	2 to 4%	Slight	IIe	.43	3	90	30	40	-	3.8	190
14C	4 to 7%	Slight	IIe	.43	3	90	30	40	-	3.8	190
14C2	4 to 7%	Eroded	IIe	.43	3	80	28	35	-	3.5	175
14D2	7 to 12%	Eroded	IIIe	.43	3	75	25	35	-	3.2	160
14D3	7 to 12%	Sev. eroded	IVe	.43	2	60	-	28	-	2.5	125
14E2	12 to 18%	Eroded	IVe	.43	3	60	-	28	-	2.8	140

SUITABILITY FOR WILDLIFE

Openland wildlife	WELL SUITED on 2 to 12 percent slopes - well suited to several species of wild herbaceous plants, hardwood woody plants, grain and seed crops, grasses, and legumes. SUITED on 12 to 18 percent slopes - moderate limitation for grasses and legumes and severe for grain and seed crops.
Woodland wildlife	WELL SUITED on 2 to 12 percent slopes - well suited to several species of hardwood woody plants and wild herbaceous plants. SUITED on 12 to 18 percent slopes - slope is moderate limitation for production of grasses and legumes; rapid growth of coniferous woody plants causes early canopy closure.
Wetland wildlife	UNSUITED: Moderately well drained gently sloping to moderately steep soil; few, if any, suitable plant species for wetland food and cover; water table too deep for shallow water developments.

LIMITATIONS FOR RECREATION 1/

Cottages and utility buildings	SLIGHT on 2 to 7 percent slopes. MODERATE on 7 to 12 percent slopes; slopes limit use. SEVERE on slopes exceeding 12 percent; slopes severely limit use.
Tent and camp trailer sites	MODERATE on 2 to 12 percent slopes; slopes limit use. SEVERE on slopes exceeding 12 percent; slopes severely limit use; turf difficult to maintain.
Picnic areas	SLIGHT on 2 to 7 percent slopes. MODERATE on 7 to 12 percent slopes; slopes limit use. SEVERE on slopes exceeding 12 percent; slopes severely limit use; turf difficult to maintain.
Playgrounds	MODERATE on 2 to 7 percent slopes, slopes limit use. SEVERE on slopes exceeding 7 percent; slopes severely limit use.
Paths and trails	SLIGHT on 2 to 12 percent slopes.) Paths and trails not on the contour are MODERATE on 12 to 18 percent slopes; slopes limit use.) subject to erosion under heavy use.
Golf course fairways	SLIGHT on 2 to 7 percent slopes. MODERATE on 7 to 12 percent slopes; slopes limit use. SEVERE on slopes exceeding 12 percent; slopes severely limit use; turf difficult to maintain.

LIMITATIONS FOR SOME OTHER USES 1/

Residential, commercial and light industrial development with public sewers	MODERATE on 2 to 12 percent slopes. Fair to poor stability; slight to moderate grading for streets and lots; excavation exposes highly erodible material; foundations, slabs, walks, and streets subject to cracking. SEVERE on 12 to 18 percent slopes. Severe erosion and siltation during construction.
Septic tank filter fields	SEVERE: Slow permeability in lower part of subsoil; 2 to 18 percent slopes; percolation rate is slower than 60 minutes per inch; hazard of effluent seeping out downslope.
Sewage lagoons	MODERATE on 2 to 7 percent slopes. Slope affects design and construction. SEVERE on slopes exceeding 7 percent. Slope severely limits construction.

1/ The soil is evaluated to a depth of five feet. Soils are rated on the basis of three classes of soil limitations: Slight - relatively free of limitations or limitations are easily overcome; Moderate - limitations need to be recognized, but can be overcome with correct planning and careful design; Severe - limitations are severe enough to make use questionable. (Severe may be further subdivided into Severe and Very Severe where needed.) Ratings may be changed as additional experience and data are obtained. USE OF INFORMATION ON THIS SHEET DOES NOT ELIMINATE THE NEED FOR ON-SITE INVESTIGATIONS.

USDA-SCS-LINCOLN, NEBR. 1973

Figure 6 (con't)

Obtaining Relevant SCS Products

Appendix B provides the status of published soil surveys as of January 1977 for the counties in which major U.S. Army FORSCOM-TRADOC installations are located. However, the most current information on the status of soil maps for a particular area is available from county agricultural extension offices or from state conservationists. (For addresses and phone numbers of state conservationists, see CERL Technical Report N-40, *Compendium of Administrators of Land Use and Related Programs,* July 1978, under Appendix B, individual state listings, #7, Agricultural Lands Classification.) Even if no soil survey is available for a particular area, the district conservationist may still be of assistance. Since 10 years or more are often required to complete a county survey, copies of working materials might be obtained from in-progress studies. If no soil survey mapping has been done for a particular county, it may be possible (with the assistance of Soil Conservation Service personnel) to extrapolate information about a particular site from general soil maps and/or soil interpretation sheets. It is also possible to make some soil interpretations from geological, topographical, and drainage maps as well as from aerial photographs.

If available, general soil maps, soil interpretation sheets, and published soil surveys may be obtained free-of-charge from local offices of the SCS, the state conservationist, or the county agricultural agent. Although many early surveys are now out of print, copies are frequently available from libraries.

Vegetation Maps

There are several possible approaches to mapping a landscape's plant communities. A vegetation map may show either the actual vegetation occurring on the landscape at the time of observation or the potential natural vegetation (that is, the stable or climax plant community) that would exist if the effects of man were removed and natural succession could occur with no climatic or geologic changes. It is useful to know the potential natural vegetation, since such information may provide insight into how man's activities affect a particular landscape; however, for analysis purposes, actual vegetation maps are more useful. There are also different mapping techniques to describe the vegetative landscape. Physiognomic maps indicate types of vegetation, such as grasslands, shrub, or forest, as well as their height, density, and character; floristic maps indicate which species are present. There are also combined physiognomic-floristic maps, usually with colors indicating physiognomy and symbols indicating floristic composition. Each type has a specific purpose. Combination maps are the most versatile for environmental analysis; however, they can be difficult to read because they include so much information.

No agency produces large-scale vegetation maps for the entire United States; however, there are a few sources for some small-scale maps, such as A. W. Kuchler's "Potential Natural Vegetation" (1967) appearing in USGS's National Atlas at a scale of 1:7,500,000, and "Ecosystems of the United States" (1976), by R. G. Bailey for the U.S. Forest Service, which is also at a scale of 1:7,500,000. There are also some useful general reference documents on vegetation mapping. Kuchler's *International Bibliography of Vegetation Maps Volume 1, North America* (University of Kansas, 1968) lists all published vegetation maps at all scales by state and province and also provides some information about the type of mapping employed. Kuchler's *Vegetation Mapping* (Ronald Press, 1967) discusses all aspects of vegetation mapping and has an extensive bibliography. However, the maps listed in Kuchler's bibliographies are generally specific-purpose maps that are unique to a particular area. Few are likely to be of value to installations.

Vegetation as a Component of the USGS and DMATC Topographic Maps

USGS topographic contour maps indicate some types of vegetation, but are not adequate for quantitative analysis of landscape vegetation. The symbol key from the USGS 1976 publication *Topographic Maps* (Figure 3) shows color and pattern symbols for woods or brushwood, submerged marsh, orchard, vineyard, mangrove, scrub, and wooded marsh. However, no information is provided about the physiognomy or the floristics of these vegetative communities; thus, a map reader may see the green woodland tint for an area but has no way of knowing if the woodland is sparse or dense or if the trees are deciduous or coniferous. Orchards and vineyards are indicated, but land used for crops, range, or pasture is not; also, for many areas, the maps do not indicate vegetation at all. DMATC maps provide essentially the same information.

Fish and Wildlife Vegetation Maps

The U.S. Department of the Interior Fish and Wildlife Service eventually plans to produce vegetation maps at a scale of 1:100,000 for the entire United States. The first of these maps are being developed in connection with a National Wetlands Inventory for certain coastal areas of the United States. The Fish and

Wildlife Service has produced a full-color prototype map of an area of coastal Louisiana but in the future will use black-and-white maps only, because of the prohibitive printing and production costs of full-color maps. The Fish and Wildlife Service's 1:100,000 map series employs the USGS 1:100,000 quadrangle format. The 1:100,000 maps have the same relationship to the 1:250,000 quadrangles as the 7.5 minute series quadrangles have to the 15-minute series quadrangles. That is, each 1:250,000 quad, which is 1° north-south by 2° east-west is divided into four quadrants, each 1/2° north-south by 1° east-west. Currently, only a few scattered areas of the United States are mapped by USGS at the 1:100,000 quadrangle scale, with none in areas having major military installations; however, the USGS intends to map the entire United States at this scale eventually. (A free index map, "Status of Intermediate Scale Quadrangle Mapping," can be obtained from any National Cartographic Information Center [NCIC] office.) When USGS topographic maps are available, the Fish and Wildlife vegetation maps will be printed on mylar base and will overlay on the USGS series. While the mylar base is stable, humidity may cause the paper topographic map to shrink and swell, causing minor registration problems. Eventually, the USGS may incorporate the vegetation categories mapped by the Fish and Wildlife Service into its regular topographic series. The Fish and Wildlife Service also plans to map some areas at the 1:24,000 scale, for use as overlays for the USGS maps. The first of these maps was published late in 1978. These vegetation maps are usually compiled from existing aerial photography (color infrared, and/or black-and-white panchromatic), but where existing imagery is inadequate, new aerial photographic missions are flown.

A complete set (450) of 1:250,000 quadrangle maps defining ecoregions and land forms is also available, in blueprint copy only, from the Fish and Wildlife Service's St. Petersburg Office. The ecoregions are adapted from Bailey's 1976 "Ecosystems of the U.S.," and the land forms from Hammond's 1964 "Classes of Land-Surface Forms."

At this time, no publication describes the fish and wildlife vegetation mapping program, the types of vegetation categories employed, or the areas where mapping is in progress. For additional information, contact one of the following:

Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240
FTS or Commercial 634-4910; or

National Wetlands Inventory
Fish and Wildlife Service
U. S. Department of the Interior
Suite 217, Dade Building
9620 Executive Park Drive North
St. Petersburg, FL 33702
Commercial (813) 893-3624 or FTS 826-3624.

Forest Service Vegetation Maps

The U.S. Department of Agriculture's Forest Service produces vegetative cover maps of all national forests to aid timber and wildlife management and for recreational use. Such maps are of special interest to those military installations that share land through various use agreements with national forests, such as Fort Polk, LA (Kisatchie) and Hunter-Liggett Military Reservation, CA (Los Padres). Forest Service maps vary according to the time they were produced and the region in which the forests occur. CERL Technical Report N-40, *Compendium of Administrators of Land Use and Related Programs*, Appendix A, gives addresses and phone numbers of all Forest Service regional offices. These offices can provide copies of Forest Service maps, information about these maps, or copies of the most recent aerial photographic imagery.

The Forest Service produced their first series of vegetation maps by contract through the USGS in 1924 and 1925. These maps were done experimentally in the 7.5-minute quadrangle format before the USGS initiated the 7.5-minute topographic series. In more recent decades, Forest Service maps have been produced through regional offices, and their contents vary from region to region. General Forest Service policy has been to produce maps for public distribution at 1/2 in. to the mile (1:126,620) and maps at 2 in. to the mile (1:31,680) or larger for Forest Service planning, timber contracts, and other purposes. In the past few years, efforts have been made, whenever possible, to use the USGS 1:24,000 quadrangle base. Essentially, the Forest Service purchases the USGS printing plates (except for the woodland plate), etches additional trails, roads, and waterways onto existing plates, and creates matching new plates for vegetation cover. Some of the newer maps may have three additional colors to indicate various vegetative types. The Forest Service has thus adapted to the USGS topographic series whenever possible, and will continue to adapt as USGS converts to the 1:100,000 scale and the 1:25,000 scale series.

The Forest Service also has aerial photographs of the national forests. Imagery obtained prior to 1973 is available through the Agricultural Stabilization and Conservation Service (ASCS) at its Salt Lake City office. Some imagery made since 1973 is also available through ASCS; if not, it can be obtained at the Forest Service regional office. New aerial photographic missions are flown for each area mapped. Imagery is obtained on 9 X 9-in. film (black and white or color) and is usually at scales of 1:15,840 and/or 1:60,000.

The large-scale Forest Service maps usually provide both physiognomic and floristic information. Recent efforts have been made to use USGS symbology on all Forest Service maps. Categories of vegetation types, however, are determined at the regional office level. For more information on the Forest Service mapping program, contact U.S. Forest Service, Drafting and Atlas Section, 1621 North Kansas St., Rosslin, VA, FTS or Commercial 238-8071, or contact the Geometronics Service Center, U.S. Forest Service, Salt Lake City, 2222 West 2300 South, P. O. Box 30010, Salt Lake City, Utah 84125, FTS 588-4140 or commercial (801) 524-4140.

Water-Related Maps

The term "water-related maps" as used here refers to any graphical source materials that concern surface or ground waters.

Water-Related Maps of the Geological Survey

The Geological Survey's Water Resources Division is involved in extensive investigations and monitoring programs throughout the United States. The division publishes water supply papers and circulars which usually include maps as well as several map series such as the "Hydrologic Investigation Atlases"; "Water Availability Maps"; "Flood Inundation Maps"; and "Water Table, Surface Drainage, and Engineering Soil Maps." Following is a brief description of some of the USGS water-related mapping programs.

The Hydrologic Investigation Atlases. This map series, prefixed by the letters "HA," is developed from special field studies and presents information on virtually all water-related topics. More than 300 atlases have been published in cooperation with state or local agencies. In recent years, the atlases have been oriented to cover natural hydrologic units, such as drainage basins; but the atlases are also often prepared with the same area coverage as topographic quadrangles. Scales are usually at 1:24,000; however, this may vary, with some as small as 1:250,000, depending on the land area covered, the format size, and the available topographic or planimetric base. Topics considered include flood frequency and extent, groundwater availability and quality, geohydrology of aquifers, annual precipitation and runoff, surface water quality, and water use. Subjects investigated usually depend on the needs and priorities of the cooperating local agency. Scattered areas throughout the United States have been mapped.

An innovative and imaginative range of formats and techniques displays information in these atlases. Single- or multi-colored maps are supplemented by illustrations, graphs, tables, diagrams, cross sections, texts, and references. More of the information presented is oriented toward quantitative analysis. Frequently, bar and table graphs are inserted or superimposed directly on the main map. These atlases are sometimes published as single sheets, sometimes as multiple sheets, and sometimes as bound documents.

Water Availability Maps. This series of maps is prepared on a 1:250,000 scale planimetric base. Each map indicates the gallons per minute yield per well and, when enough information is known, the depth to groundwater level. The maps are intended as guides in water use planning, and mapping activities are concentrated in areas where population and water use are growing rapidly.

Flood Inundation Maps. These maps, which help individuals and Government agencies solve flood problems and establish flood plain policies, illustrate on a topographic base areas inundated by particular historical floods. Graphs and profiles supplement maps. The major mapping program in this series was done in northern Illinois in the 1960s, but other flood-prone areas have also been mapped. Several thousand topographic maps have also been prepared for various localities that simply outline flood-prone areas.

Water Table, Surface Drainage, and Engineering Soil Maps. This mapping program is limited, with a few exceptions, to the State of Delaware. On a topographic base, these maps indicate position of the water table, the surface drainage system, and the engineering classifications of soils. Designed to provide information related to engineering problems in road construction, urban development, and water supply, this mapping program has, to some extent, been reoriented to interpretation for planners and continued by the Earth Science Application Program. Maps of the Earth Science Application Program are published under the title "Folios of Land Resource Analysis" and discussed under the section on geologic maps.

Obtaining USGS Water-Related Materials. The Geological Survey's Branch of Distribution offices listed in this report under "Topographic Maps" have available free, upon request, catalogs of all the survey's publications: *Publications of the Geologic Survey 1879-1961, Publications of the Geological Survey, 1962-1970,* annual volumes for subsequent years, and since 1973, monthly updates. These catalogs are organized into two sections. Section 1–"Reports"– includes annual reports, monographs, professional papers, bulletins, water supply papers, and circulars. Section 2–"Maps, Charts, and Atlases"–includes coal investigation maps, index maps, geologic quadrangle maps, hydrologic investigation atlases, hydrologic unit maps, mineral investigation resource maps, miscellaneous investigation series, and oil and gas investigation charts and maps. Because these catalogs list publications (including maps) by series and chronologically assigned number rather than by geographic area, they can be time-consuming to search.

Also published periodically (usually annually) are lists of state geological surveys, entitled "Geologic and Water supply Reports and Maps." These lists are again organized by series, but the geographic scope is limited to each particular state. (Appendix C is the result of reviewing copies of the most recent editions of these state lists.) Also available for water-related topics are folders labeled "Water Resource Investigations" periodically published for each state by the USGS Water Resource Division's District Offices. These two publications are available at no charge from the USGS Water Resource Division District Offices. A list of District Offices is provided in CERL Technical Report, *Water Quality Data for Army Military Installations* (CERL Technical Report N-63, February 1979). The phone numbers and addresses can also be obtained from the National Resources Information Office at the Geological Survey's national headquarters in Reston, VA (commercial phone number [703] 860-6867 or FTS 928-6867).

The "Water Resource Investigation" folders mentioned above include an outline map of the areas of current hydrological investigation and list all water-related reports and maps published by USGS and by cooperating state and local agencies. These folders are the most comprehensive published reference source for state materials on water-related topics. However, personnel at the relevant USGS Water Resources Division District Office may provide the most current and useful information, since they will know about reports in progress as well as about published materials. It is recommended that the District Offices be consulted first.

Another information source is the Water Resource Scientific Information Center, Office of Water Resource and Technology, Department of the Interior, WASH DC 20240. This organization publishes bimonthly listings of all water-related reports and, upon request, performs bibliographic searches of all water-related reports by county, river basin, or state.

Water-Related Maps Published by National Oceanic and Atmospheric Administration (NOAA) Nautical and Aeronautic Charts

Information about these maps can be obtained by contacting the National Ocean Survey, U.S. Department of Commerce, Distribution Division (C-44), National Ocean Survey, 6501 Lafayette Avenue, Riverdale, MD 20840, telephone (301) 436-6990, or Director of National Ocean Survey, National Oceanic and Atmospheric Administration, Rockville, MD 20852, or Department of Defense organizations through the Defense Mapping Agency, Hydrographic Center, St. Louis, MO.

Nautical charts are intended chiefly as navigation aids, and are of use only to those installations that border navigable waterways. In addition to navigational charts, NOAA can provide tide tables, tide turn tables, tidal current charts, and tidal current diagrams. The National Ocean Survey has prepared nautical charts for all U.S. coastal waterways. The following catalogs are available without charge to help users obtain particular nautical charts.

Catalog #1–"Atlantic and Gulf Coasts, Including Puerto Rico and the Virgin Islands"

Catalog #2–"Pacific Coast, Including Hawaii, Guam, and Samoa Islands"

Catalog #3–"Alaska, Including the Aleutian Islands"

Catalog #4–"Great Lakes and Adjacent Waterways."

Also available without charge is a quarterly publication, *Dates of Latest Editions,* which indicates all map updates. Since coastal conditions change constantly, the charts are constantly being updated. Minor changes result in revised prints, with the date of the revision indicated to the right of the edition date. Major changes that are significant to navigation result in a new edition which cancels all previous editions. New navigational

aids or changes in channels are first listed in the weekly "Notice to Mariners," published nationally by the Defense Mapping Agency's Hydrographic Center, and locally by the U.S. Coast Guard Districts. Generally, these navigational charts cost $3.25 each.

In addition to mapping nautical charts, the National Ocean Survey has a variety of special-purpose maps. Catalog #5, "Bathymetric Maps and Special Purpose Charts," may be obtained free from the National Ocean Survey. Bathymetric maps differ from the nautical charts in that they show relief on the sea bottom by contour lines and tints, rather than soundings. Also available are off-shore mineral leasing maps, nautical training charts, and outline continental and shelf base maps at various projections.

Water-Related Maps of the Corps of Engineers

Another possible source of relevant graphic materials is the Corps of Engineers. The various Corps Districts make maps of rivers and adjacent lands for their flood control projects, as well as maps of entire watersheds for particular drainage basin studies. The Corps also does special projects specifically for installations, such as preparing large-scale cartonment area maps, but information on such maps would be available on-post. There is no central information file or index for these Corps-produced materials; therefore, to investigate the possibility of any available relevant materials, the best course of action would be to contact the appropriate District office directly. To obtain information on District and Division boundaries and offices, the document, *Corps of Engineers Agencies* (ER-1-1-14) is available from the Office of the Corps of Engineers (OCE) Publications Depot, 890 S. Pickett St., Alexandria VA 22304. This document, which is frequently updated, includes phone numbers, addresses, office hours, officer in charge for each agency, and a jurisdiction boundary map.

Geologic Maps

The term "geologic map" is used here to refer to any map that illustrates features of the lithosphere, as it lies beneath or protrudes above surface vegetation and soil.

Maps of the USGS

The USGS is the major Federal agency producing geologic maps. However, these maps are produced in cooperation with other Federal and state agencies. The USGS, through its topographic mapping program, has sought to produce and update uniform land surface maps of all areas of the United States at multiple scales; however, its geologic mapping program is sporadic in coverage, and produces a variety of map types and scales. The USGS has published maps that cover the entire United States at a scale of 1:2,500,000; however, the level of generalization of these maps prohibits environmental analysis except on a very large regional basis. The agency is now emphasizing completion of an intermediate-scale nationwide mapping program, using the 1:250,000 quadrangle format. Appendix D matches the 1:250,000 quadrangle maps listed in Appendix A with the most recently available (July 1978) updated index sheets from USGS.

USGS publishes maps relating to the subsurface in several larger-scale formats, among which are geologic quadrangle maps, mineral investigation maps, mineral resource maps, oil and gas investigation maps, coal investigation maps, geophysical investigation maps, special geologic maps, and hydrologic investigation atlases. In addition, various folded sheet maps are included in the published bulletins, water supply papers, professional papers, and circulars of USGS. Many of these geologic mapping formats are for specific purposes, such as obtaining estimates of ground water availability for water use planning and estimating coal seam thickness and grade for making appropriate lease contracts. These special-purpose maps apply only to specific military installations; the mapping programs of greatest interest are the geologic quadrangle series and the miscellaneous geologic investigation series.

Geologic Quadrangle Series. Each map in this series is designated by a "GQ" and a number which indicates the publication sequence within the series. These maps are constructed at either the 1:24,000 or 1:62,500 topographic quadrangle format. Coverage is available only for sporadic quadrangle. To date, fewer than 1000 maps have been published; however, if available, these maps provide essential information for many environmental analysis purposes.

Maps in this series may differ somewhat in content, but generally they illustrate the uppermost rock units without the soil cover.

GQ-780, the geologic quadrangle map for Rock Haven and an adjoining corner of Laconia quadrangle, KY-IN, includes the western portion of Fort Knox. USGS cooperated with the University of Kentucky and the Kentucky Geological Survey to produce this map. The map was printed with brown surface contour lines, black lettering, and blue water features from the

topographic contour map, and then over-printed with color plates for various geological formations. Included on the maps are structural contours for a subsurface baserock (New Albany shale) and symbols for faults, strikes and dip beds, quarries, gravel pits, oil seeps, and oil and gas exploratory holes. These are extensive marginal illustrations and notes, including a brief text on local economic geological activities (i.e., oil recovery and surface mining), a cross-sectional diagram, and a complex log that describes, locates in terms of depth and thickness, and orients in terms of time of deposition, the formation of each geologic unit illustrated in the quadrangle map.

Miscellaneous Geologic Investigation Series. This series, which is of assistance to land use planners, contains a diversity of subject matter, sheet size, scale, and geographic area. Mapping activities have concentrated in areas where subsurface information is critical in land use, such as areas where problems occur with ground water supply or quality or where slumping, landslides, or earthquakes have occurred. Subject matter in this series is not always limited to subsurface features. Some maps in this series illustrate vegetation, urban growth, soil associations, or other features pertinent to land use planning.

These maps are often printed as folios in which a number of map sheets, each featuring a different environmental component, are constructed for one area, using the same quadrangle format and scale. Figure 7 provides lists of maps contained in two land resource analysis folios from a July 1974 USGS brochure entitled "Folios of Land Resource Analysis Maps." Salina Quadrangle, Utah, is a scale of 1:250,000, and Golden Quadrangle, Colorado, is at 1:24,000.

Obtaining Information on Available Geologic Maps

State agencies frequently cooperate with the USGS in compiling or producing geologic maps, but many also produce and prepare their own. Appendix E lists the phone numbers and addresses to contact for each of the 50 states and Puerto Rico. In many cases, this contact will be the most effective method to obtain

Folio of the Salina Quadrangle, Utah. Scale 1:250,000.

I-591. Geology, structure and uranium deposits.
(Two sheets, available as a set for $3.25; when reprinted will be available as individual sheets, I-591-A and -B.)
I-591-C. Topographic relief map.
I-591-D. Map showing normal annual and monthly precipitation.
I-591-E. Map showing length of freeze-free season.
I-591-F. Surface water map.
I-591-G. Map showing springs.
I-591-H. Map showing types of bedrock and surficial deposits.
I-591-I. Maps showing extent and thickness of coal beds and amount of overburden on coal beds.
I-591-J. Map showing relative ease of excavation.
I-591-K. Map showing general chemical quality of ground water.
I-591-L. Map showing landslides and areas of potential landsliding.
I-591-M. Map showing general availability of ground water.
I-591-N. Map showing drainage basins and historic cloudburst floods.
I-591-O. Map showing scenic features and recreation facilities.
I-591-P. Vegetation map.

Folio of the Golden Quadrangle, Colorado. Scale 1:24,000.

I-761-A. Surficial and bedrock geologic map.
I-761-B. Map showing landslides.
I-761-C. Map showing areas of potential rockfalls.
I-761-D. Map showing earth materials that may compact and cause settlement.
I-761-E. Map showing man-modified land and man-made deposits.

Figure 7. Lists of maps in two land resource analysis maps.

information on the availability of geologic maps within a particular state.

From 1975 to the present, USGS has been publishing indexes of all available geological maps for each state. These indexes reference map title, publisher, author, source, map type, and ordering information. They may be obtained, when available, from the USGS's Branch of Distribution offices. Appendix F is compiled from those indexes currently available. Appendix C, which includes only USGS publications, was assembled from the state lists of "Geologic and Water Supply Reports and Maps." These lists are issued periodically for each state as new publications become available (see the previous section on water-related maps).

Army-Unique Sources

The two major U.S. Army-unique resources for graphic materials are the Defense Mapping Agency (DMA) and the Engineer Topographic Laboratories. In addition, some engineer detachments stationed at certain installations provide graphic services and materials, such as the 64th Engineer Detachment (Terrain) and the 524th Engineering Company (Topo), stationed at Fort Hood, TX. Both the DMA and the Engineer Topographic Laboratories provide a variety of services and materials for installations. This section discusses the topographic maps produced by the DMA Topographic Center and the terrain analysis reports produced by the Engineer Topographic Laboratories Terrain Analysis Center.

Defense Mapping Agency–Topographic Maps

Defense Mapping Agency Topographic Center
ATTN: 55500
6500 Brooks Lane
Washington, DC 20315
Phone 202-227-2495 or 2496

Description. These are multicolored maps having the terrain surface indicated by contour lines. They are bounded by parallels of latitude and meridians of longitude, but overprinted with a UTM grid.* These maps include information on drainage, vegetation, roads, urban areas, political boundaries, and other cultural features.

Scale. The scales used for an installation are generally 1:25,000 and 1:50,000. Some areas are also mapped at a variety of other scales.

Coverage. While not all areas of the United States are covered by DMA's topographic maps, most Army installations and facilities have been mapped. DMA also produces topographic maps for areas throughout the world that are of special interest to the United States.

Updating. DMA maps are frequently updated, depending on U.S. Army needs and uses.

Cost. DMA products are available free of charge to Department of Defense agencies. To send out materials, DMA must have authorized orders, preferably Standard Form 344. Maps are also available to the public at $1.85 per sheet.

Special DMA Features. DMA topographic maps provide essentially the same information as USGS topographic maps. The major differences are the standard large scale for DMA (1:25,000 and 1:50,000, as opposed to USGS's 1:24,000 or 1:62,500) and the overprinting of the UTM grid. The UTM grid overprint facilitates geographic referencing and is therefore useful for artillery sighting and other specific Army uses. USGS is now considering overprinting UTM grids on its maps. However, USGS maps indicate township and range lines, which DMA maps omit.

DMA publishes a series of maps which center installations, as much as possible, on a single sheet. Since several standard sheets are often required for an entire installation, these special maps are more convenient and manageable, especially for field use.

Figures 8 and 9 are the most recent listings from Part 3, Volume 5 of the DMA map catalog of special maps covering military installations in the United States. Figure 8 is from Section 2, 1:50,000 scale and smaller; Figure 9 is from Section 3, 1:25,000 scale and larger. DMA is currently cooperating with USGS to publish several more special maps for installations based on pertinent USGS 1:24,000 quadrangle maps at both the 1:25,000 and 1:50,000 scales. In addition, other special maps, such as the Fort Knox, KY, 1:50,000 special map compiled in 1966 by the Army Map Service (predecessor agency to DMA), are still

*The Universal Transverse Mercator (UTM) is a coordinate grid system which divides the earth between 84°N and 80°S latitude into 60 north-south zones, each 60° longitude wide. The UTM system further divides into 6° longitude X 8° latitude quadrilaterals, called grid zones, identified by reference numbers and letters, which are again subdivided in 100,000 meter squares which also have identifying letter combinations. The Universal Polar Stereographic grid (UPS) similarly divides the poleward regions of the earth. For further information, consult the Department of the Army manual, *Grids and Grid References*, TM 5-241-1, published in 1967.

*Denotes a new or revised map.

UNITED STATES SPECIALS

VOLUME V — WESTERN HEMISPHERE   SECTION 2 — 1:50,000 SCALE AND SMALLER

SPECIAL MAPS COVERING U.S. MILITARY INSTALLATIONS ARE USUALLY AT THE SCALE OF 1/50,000. SHEETS HAVE VARIOUS FORMATS, UTM GRIDS, AND ARE USUALLY MADE FROM DMATC OR US GEOLOGICAL SURVEY MAPS. SYMBOLIZATION IS DMATC WITH SOME ADDITIONAL SPECIAL SYMBOLS. CONTOURS AND SPOT HEIGHTS ARE IN FEET. VEGETATION IS USUALLY SHOWN. MANY SHEETS HAVE SPECIAL OVERPRINTS SHOWING FIRING RANGES, DROP ZONES, ETC. ORDER SHEETS BY STOCK NUMBERS LISTED BELOW.

COORDINATES ARE GIVEN IN DEGREES AND MINUTES

STATE AND NAME	SERIES	SCALE	NORTH	WEST	STOCK NUMBER	ED.
ARIZONA						
CIBOLA RANGE.............	V798S	1/50,000	32 45	114 35	V798SCIBOLARA	01
FT. HUACHUCA.............	V798S	1/50,000	31 32	110 10	V798SFTHUACHU	02
CALIFORNIA						
FRITZSCHE ARMY AIRFIELD, FORT ORD						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V603	1/100,000	36 41	121 46	V603XFRITZSCHEA	01
HUNTER-LIGGETT...........	V795S	1/50,000	35 57	121 12	V795SHUNTERLI	01
MARINE CORPS BASE						
TWENTY NINE PALMS EAST.	V795S	1/50,000	34 37	116 07	V795S29PALMSE	01
TWENTY NINE PALMS WEST.	V795S	1/50,000	34 45	116 30	V795S29PALMSW	01
SHARPE ARMY AIRFIELD, SHARPE ARMY DEPOT						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V603	1/100,000	37 50	121 17	V603XSHARPEARMY	01
COLORADO						
BUTTS ARMY AIRFIELD, FORT CARSON						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V701	1/50,000	38 41	104 46	V701XBUTTSARMYA	01
FORT CARSON..............	V771O	1/50,000	38 41	104 50	V771OFTCARSON	02
KANSAS						
FORT RILEY...............	SUBSTITUTE V778X65621, 65622, 66623 & 66624					
MASSACHUSETTS						
MOORE ARMY AIRFIELD, FORT DEVENS						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V603	1/100,000	42 35	71 36	V603XMOOREARMYA	01
MINNESOTA						
CAMP RIPLEY..............	V772S	1/50,000	46 12	94 22	V772SCAMPRIPL	01
MISSOURI						
FORNEY ARMY AIRFIELD, FORT LEONARD WOOD						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V603	1/100,000	37 45	92 09	V603XFORNEYARMY	01
NEW YORK						
CAMP DRUM................	V721S	1/50,000	44 07	75 36	V721SCDRUMVC	01
WEST POINT...............	V721S	1/50,000	41 22	74 00	V721SWESTPT	01
OKLAHOMA						
FORT SILL						
SPECIAL MAP..............	V783S	1/50,000	34 32	98 47	V783SFTSILL	01
RANGE MAP................	V783S	1/50,000	34 41	98 31	V783SFTSILLRM	01

COORDINATES ARE GIVEN IN DEGREES AND MINUTES

STATE AND NAME	SERIES	SCALE	NORTH	WEST	STOCK NUMBER	ED.
SOUTH CAROLINA						
COLUMBIA METRO, FORT JACKSON						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V603	1/100,000	33 56	81 07	V603XCOLUMBIA	01
TENNESSEE						
FORT CAMPBELL VICINITY						
ORTHOPHOTO MAP..........	V048	1/50,000	36 30	87 50	V048XFTCAMPBELL	01
SPECIAL MAP..............	V741S	1/50,000	36 30	88 00	V741SSPECIAL	01
TEXAS						
FORT HOOD						
TRAINING MAP.............	V782S	1/50,000	31 00	97 55	V782SFTHOODTR	04
WASHINGTON						
FT. LEWIS................	V791S	1/50,000	47 01	122 35	V791SFTLEWIS	02
GRAY ARMY AIRFIELD, FORT LEWIS						
AIR-CRASH						
SEARCH-&-RESCUE MAP..	V603	1/100,000	47 05	122 35	V603XGRAYAAF	01
WISCONSIN						
CAMP MCCOY...............	V761S	1/50,000	44 01	90 38	V761SCMPMCCOY	04

Figure 8. DMA special maps—1:50,000 and smaller.

*Denotes a new or revised map.

UNITED STATES SPECIALS

DMA MAP CATALOG—PART 3
To Order This Index
*STOCK NO. TSCSX3USSPEC

VOLUME V — WESTERN HEMISPHERE   SECTION 3 — 1:25,000 SCALE AND LARGER

SPECIAL MAPS COVERING U.S. MILITARY INSTALLATIONS ARE USUALLY AT THE SCALE OF 1/25,000. SHEETS HAVE VARIOUS FORMATS, UTM GRIDS, AND ARE USUALLY MADE FROM DMATC OR US GEOLOGICAL SURVEY MAPS. SYMBOLIZATION IS DMATC WITH SOME ADDITIONAL SPECIAL SYMBOLS. CONTOURS AND SPOT HEIGHTS ARE IN FEET. VEGETATION IS USUALLY SHOWN. MANY SHEETS HAVE SPECIAL OVERPRINTS SHOWING FIRING RANGES, DROP ZONES, ETC. ORDER SHEETS BY STOCK NUMBERS LISTED BELOW.

COORDINATES ARE GIVEN IN DEGREES AND MINUTES

STATE AND NAME	SERIES	SCALE	NORTH	WEST	STOCK NUMBER	ED.
CALIFORNIA						
FORT ORD.................	V895S	1/25,000	36 38	121 45	V895SFTORDVIC	05
SAN CLEMENTE IS. 1.......	V899	1/25,000	32 55	118 30	V899X1	01
SAN CLEMENTE IS. 2.......	V899	1/25,000	32 55	118 30	V899X2	01
COLORADO						
AIR FORCE ACADEMY........	V877S	1/25,000	39 00	104 53	V877SAFACAD	02
MASSACHUSETTS						
CAMP EDWARDS.............	V814S	1/25,000	41 42	70 32	V814SCPEDWARD	01
FORT DEVENS..............	V814S	1/25,000	42 30	71 37	V814SFTDEVENS	01
MICHIGAN						
CAMP GRAYLING 1..........	V862S	1/25,000	44 39	84 47	V862SCPGRAYL1	01
CAMP GRAYLING 2..........	V862S	1/25,000	44 39	84 47	V862SCPGRAYL2	01
CAMP GRAYLING 3..........	V862S	1/25,000	44 39	84 47	V862SCPGRAYL3	01
NEW YORK						
WEST POINT...............	V021S	1/25,000	41 22	74 03	V021SWESTPOIN	05
WEST POINT...............	V821S	1/25,000	41 22	74 02	V821SWESTPT	09
WEST POINT PICTOMAP	V8210S	1/25,000	41 22	74 02	V8210S	09
TEXAS						
LEON SPRINGS.............	V882S	1/25,000	29 42	98 34	V882SLEONSPRI	04
VIRGINIA						
CAMP A.P. HILL...........	V834S	1/25,000	37 02	77 55	V834SAPHILLFR	03
CAMP PICKETT.............	V834S	1/25,000	44 01	90 38	V834SCAMPPICK	02
FT BELVOIR...............	V834S	1/25,000	38 43	77 10	V834SFTBELVOI	02
MARINE CORPS BASE						
QUANTICO.................	V834S	1/25,000	38 28	77 15	V834SQUANTICO	01
QUANTICO-SPECIAL.........	V834S	1/25,000	38 28	77 15	V834SQUANTIFR	01

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Figure 9. DMA special maps: 1:25,000 and larger.

used at installations, but are out of print or not in general circulation through DMA.

DMA catalogs are divided into parts, volumes, and sections, and each topographic map has a combined stock number, series number, and sheet number. Part 3 is Topographic Products, Volume 5 is the Western Hemisphere, and Sections 1 and 2 concern North and Central America. There are multi-state regional index sheets for maps of 1:50,000 and smaller, 1:25,000 and larger, and indexes for city maps. Areas for which published maps are available are shaded on these index sheets; however, these base maps onto which the index sheets are printed offer few geographic landmarks (i.e., no state and county boundaries are indicated); thus, it may be difficult to determine if a known site has been mapped.

U.S. Army Engineer Topographic Laboratories–Terrain Analysis Reports

The Terrain Analysis Center
U.S. Army Engineer Topographic Labs (ETL)
Fort Belvoir, VA 22060, (202) 664-5073

The Terrain Analysis Center is producing a series of large-format documents consisting of several maps and associated texts and tables, one for each of several major U.S. Army installations. This project, initiated at FORSCOM headquarters in 1974 and 1975, is called "Terrain Analysis of Selected CONUS Army Installations." The purpose of these reports is to assist military planners in future stationing decisions, but some of the information will also facilitate environmental analysis. For such purposes, however, the user is cautioned that while the studies may contain some environmental baseline data, they are by no means environmental inventories of the type required for comprehensive impact assessment. This series was originally to include 13 FORSCOM installations, but has been expanded to include some TRADOC installations also. As of July 19, 1978, the following installations are included:

1. Fort Benning, GA
2. Fort Stewart, GA
3. Fort Lewis, WA, including Yakama Firing Center and Camp Bonneville
4. Fort Ord, CA, including Hunter-Liggett Military Reservation and Camp Roberts
5. Fort Polk, LA, including Peason Ridge
6. Fort Hood, TX
7. Fort Bragg, NC
8. Fort Drum, NY
9. Fort Campbell, KY
10. Fort Riley, KS
11. Fort Carson, CO
12. Fort Erwin, CA
13. Fort McCoy, WS
14. Fort Wayne, AK
15. Fort Bliss, TX
16. Fort AP Hill, VA
17. Fort Knox, KY
18. Fort Jackson, SC

Several of these reports are now published (Fort Benning, September 1976; Fort Stewart, December 1976; Fort Drum, October 1977; Fort Hood, July 1977; Fort Bragg, November 1977; Fort Riley, December 1977; Fort Carson, January 1978; Fort Campbell, March 1978; and Fort Polk, April 1978).

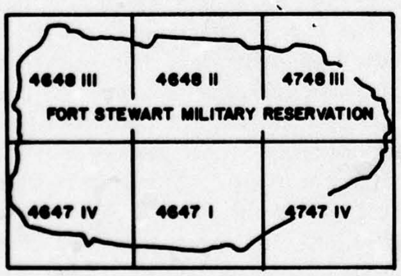
All of the work for these reports is coordinated under the technical direction of the ETL Terrain Analysis Center (TAC), so the format and content are consistent for the entire series. The first reports (Fort Benning, Fort Stewart and Fort Drum) were prepared by TAC. Many of the other reports were or are being prepared by commercial contractors or by other Army units.

Figure 10 is a copy of the table of contents from the Fort Stewart Terrain Analysis Report. With slight variations, this table of contents is consistent for each report in the series. Also, in most cases, the base and scale used are from the 1:50,000 DMA map series. In many reports, the DMA special is also used (for example, in both the Fort Riley and the Fort Drum reports). The Fort Benning special was too large for the standardized publication format; however, the special map was used and the map pages simply fold out. In the Fort Stewart and Fort Hood reports, the standard quadrangle format sheets from DMA were used, and each map topic was segmented onto several sheets. Diagrams on the contents page (as reproduced in Figure 11 for Fort Stewart), indicate the installation boundaries in relation to DMA quadrangle map sheets.

Detailed information is offered on each of the topics considered, both in text and tables. Maps (all of the same scale) are included in each report for surface drainage, water resources (surface and ground water), engineering soils, engineering geology, vegetation,

TABLE OF CONTENTS

Figure 10. Table of contents from the Fort Stewart Terrain Analysis Report.



1:50,000-SCALE MAP INDEX

Figure 11. Fort Stewart terrain analysis report map diagram.

cross-country movement, and lines of communication. Also included are a cantonment area map at a larger scale and an off-post features map at a smaller scale. On the series of maps that use the DMA base, topography and cultural features are printed in black, water bodies in blue, and the featured information in multiple colors. Generally, the colors indicate the various area categorizations, such as vegetation type or soil type. Some of the maps are very specific, such as the surface drainage map, which indicates all major and minor engineering waterworks, gaging stations, water course widths, and river stream-bank heights at selected locations. These maps were compiled from existing sources, then augmented with the use of remote imagery and ground truth data collection in an attempt

to fill gaps in the data. The maps are as non-technical as possible. The engineering geology and engineering soils map offer specific use interpretation and avoid terminology in classification that would be meaningful only to specialists.

Because these maps are consistent (within a report) in scale and format, they are excellent for planning and analysis purposes, especially when several landscape elements must be considered. Because the maps are on an opaque paper base, it is difficult to combine them for integrated analysis; however, the binding enables the maps to be removed and placed side by side for visual comparison. Furthermore, clear plastic sheets could be overlain on these maps to redraft interpretations which combine several elements.

Aerial Photography and Other Remotely Sensed Imagery

The source materials discussed in other sections of this report represent particular aspects of the environment. Remote sensing, however, is simply the technique of obtaining information about the ground surface (in this context) from a platform (airplane or satellite) some distance abovet that landscape. Remotely sensed imagery is any product obtained from this method.

Because remote-sensing imagery replicates whatever the sensor receives, it is a non-processed source for environmental information. However, there are many options when planning remote sensing image acquisition, and each selection implies that certain elements in the landscape will be featured in the resulting imagery. These selections are analogous to some of the same selections involved in preparing maps. The selection of altitude of image acquisition affects the acquisition scale and the size of the land surface area depicted on each frame. The resolution of the imaging equipment affects acquisition scale and sharpness, and the type of sensor (photographic, electronic scan, radar, vidicon, etc.) and filter (or segment of the electromagnetic spectrum) employed affects which feature in the landscape will be most readily discerned.

Of major interest for Army installation planning and analysis are aerial mapping photography, which is available from various government and commercial sources, and satellite and high-altitude aerial photography, which is available from NASA.

Aerial Mapping Photography

Aerial photographic imagery has become a primary source of environmental information. Coverage is available for nearly all places in the United States. For most areas, imagery can be obtained at varying scales, for different seasons and years, and often for more than one or all of the following film types: panchromatic black and white, infrared black and white, panchromatic color, and color infrared. The most widely available and frequently used imagery is recorded on 9 X 9-in. black and white panchromatic film at scales of 1:40,000 and larger. This type of film, shot with images overlapping for stereo coverage, is conventionally used for topographic and other mapping purposes.

Many public and private agencies produce aerial photographs; however, information on this imagery can be difficult and time-consuming to acquire. Perhaps the best information resource is the USGS National Cartographic Information Center (NCIC), which now publishes annual catalogs which divide the United States into five north-south strips; each strip is one catalog. Alaska and Hawaii are Catalog 1, the western states are Catalog 2, the Great Plains states are Catalog 3, the midwestern and southeastern states are Catalog 4, and the mid-Atlantic and northeastern states are Catalog 5. Each catalog contains a series of index maps, one for each of the following imagery categories: Category 1: planned photography (contract has not yet been let); Category 2: photo projects in process; Category 3: photography flown in 1972 or prior, scales larger than 1:40,000; Category 4: photography flown in 1972 or prior, scales 1:40,001 through 1:75,000; Category 5: photography flown in 1972 or prior, scales smaller than 1:75,001; Category 6: photography flown in 1973 to present, scales larger than 1:40,000; Category 7: photography flown in 1973 to present, scales 1:40,001 through 1:75,000; Category 8: photography flown in 1973 to present, scales smaller than 1:75,001.

These index maps are divided along longitude and latitude lines into 15-minute quadrants. Letter symbols are used in each 7.5-minute quadrant to indicate (1) whether there is coverage of that particular area, and (2) what agency is producing or has produced coverage. These catalogs are part of NCIC's Aerial Photographic Summary Records System, called APSRS. APSRS also contains microfiche sets, each of which corresponds to one printed catalog. These microfiche sets are

computer-generated summary records of individual holdings organized into the same categories as the catalogs. Figure 12 is a sample listing and code summary from APSRS.

The National Cartographic and Information Centers (see USGS Topographic Maps section) should be contacted to order catalogs or to obtain further information about holdings from the following agencies: USGS, Bureau of Land Management (BLM), Bureau of Reclamation (BRM), U.S. Air Force, NASA, U.S. Navy, and U.S. Army.

Other agencies that produce aerial photographs, some of whose holdings are listed all or in part with APSRS, include:

U.S. Department of Agriculture
Agricultural Stabilization and Conservation Service (ASCS)
2222 West 2300 South
P.O. Box 30010
Salt Lake City, UT 84125
phone (801) 524-5866 or FTS 588-5856

U.S. Department of Agriculture, Forest Service
P.O. Box 2417
Washington, DC 20013
phone (703) 235-8638 or FTS 235-8638

U.S. Department of Agriculture, Soil Conservation service, Cartographic Division
6505 Belcrest Road
Hyattsville, MD 20782
phone (301) 436-8756 or FTS 436-8756

Defense Mapping Agency,
Topographic Center, Headquarters
Defense Mapping Agency, Building 56
U.S. Naval Observatory
Washington, DC 20305
phone (202) 254-4406, and

U.S. Department of Commerce
National Ocean Survey, NOAA
6001 Executive Building
Executive Boulevard
Rockville, MD 20852
ATTN: Coastal Mapping Division C3415
phone (301) 443-8601

To obtain holdings from these agencies, contact each one directly.

USDS's ASCS has perhaps the most extensive aerial photographic holdings in the United States. Its agency periodically publishes its own catalogs called "Comprehensive Listing of Aerial Photography." Most of this photography is flown at a scale of 1:20,000 with an 8 1/4-in. lens and recorded on panchromatic film on a county-by-county basis, usually for agriculturally active regions. Frequently, ASCS has more than one set of coverage for a particular area. To order images from ASCS, first identify the desired county and date of coverage, and then purchase the index sheets. Copies of the desired images can be selected and ordered from these index sheets.

Aerial Photography and Other Remotely Sensed Imagery–NASA Products and Programs

The NASA satellite programs have generated imagery by means of both direct photography and electronic scanning.

Skylab. Three manned and one unmanned Skylab satellites orbited the earth in 1973 and 1974 at 270 miles (430 km), acquiring both photographic and electronic-scan imagery for scattered sites. This imagery is of larger scale and generally "sharper" than Landsat Satellite imagery. This program is not ongoing, but copies of the imagery obtained are available from the EROS Data Center.

Gemini, Apollo. The various Gemini and Apollo space missions (from 1965-1969) obtained black and white and color photographic imagery of selected areas of the earth through the use of hand-held 17-mm cameras. This program is not ongoing, but copies of acceptable imagery are available from the EROS Data Center.

Landsat. The first Landsat satellite, originally called the Earth's Resources Technology Satellite (ERTS), was launched in 1972. Currently, several Landsat satellites orbit the earth every 103 minutes, or about 14 times per day, 570 miles (920 km) above the surface. Each satellite covers the entire globe, except the poles, every 18 days. Imagery is obtained by electric scanners and is then relayed to ground-based collection platforms. The ground area of each image measures 115 miles (185 km) on each side and overlaps both north-south and east-west. Imagery is acquired in four separate electromagnetic spectral bands: band 4 - green; band 5 - red; band 6 - first infrared; and band 7 - second infrared. Each band emphasizes different earth features. Products available include prints and transparencies in various bands, false-colored composites, and computer-compatible tapes.

Sample microfiche listing

AGENCY CODE	RPT TYP	Q/W	SE CORNER LAT DEG MIN	SE CORNER LONG DEG MIN	FIPS CODE ST CTY	DATE OF COVERAGE YR MO DAY	STA	AGENCY PROJECT CODE	IMAGE SCALE	FOCAL LENGT	FILM TYPE	FILM FMT	SENS CLAS	CLOUD COVER	CAM SPEC	QUAD COVER	REMARKS	RECORD NUMBER
0578	1	2	39 07	094 00	29 177	73 02	3	29177	48000	04	4	3	3	0				00000882
0578	1	2	40 07	094 00	29 081	73 11	3	29081	48000	04	4	3	3	0				00000889
2700	3	2	42 30	094 00		73 05 14	3	2380	44585	04	3	3	2	2		4		00030529
2700	3	2	42 30	094 00		73 05 14	3	2380	43414	04	2	3	2	2		4		00030529

AGENCY CODE

CA014 = Aerial Map Industries
AR005 = Arkansas State Highway Department
0560 = Agricultural Stablization & Conservation Service
1004 = Bureau of Land Management
1006 = Bureau of Reclamation
TX016 = City of Austin, Texas
0701 = Defense Mapping Agency,Topographic Command
IA018 = Iowa Geological Survey
PA002 = Keystone Aerial Surveys, Inc.
MN015 = Mark Hurd Aerial Surveys, Inc.
2700 = National Aeronautics & Space Administration
064801= National Ocean Survey
0578 = Soil Conservation Service
TX018 = Texas A&M Remote Sensing Center
0704 = U.S. Army
0703 = U.S. Air Force
1028 = U.S. Geological Survey
0596 = U.S. Forest Service
0705 = U.S. Navy

RPT TYP (Report Type)

1 = county format
2 = 7.5' quad format
3 = four corner

Q/W (Quadrant of the world)

1 = northeast
2 = northwest

SE CORNER (LAT/LONG—DEG/MIN)

Degree and minute of latitude and longitude of southeast corner of 7.5' quadrangle.

FIPS CODE (ST/CTY)

Assigned State and county numbers using Federal Information Processing Standards Publication Codes.

DATE OF COVERAGE (YR/MO/DAY)

Year, month, and day photography flown. Date reflects estimated time of completion given for planned or in-progress projects.

STA (Status)

1 = photography planned
2 = photography in-progress
3 = photography completed

AGENCY PROJECT CODE

An agency's project identification

IMAGE SCALE

Scale of photographs expressed as a whole number (some scales were derived utilizing flight height and camera focal length).

FOCAL LENGT (Focal Length)

01 = 1.75" or 44mm
02 = 3.00" or 76mm
03 = 3.46" or 88mm
04 = 6.00" or 152mm
05 = 8.25" or 210mm
06 = 12.00" or 305mm
07 = 24.00" or 610mm

FILM TYPE (Emulsion)

1 = B&W IR
2 = Color IR
3 = Color
4 = B&W
5 = Other

FILM FMT (Film Format)

1 = 2.76" or 70mm
2 = 4.5" or 11cm x 11cm
3 = 9"x 9" or 23cm x 23cm
4 = 9" x 18" or 23cm x 46cm
5 = Other

SENS CLAS (Sensor Class)

1 = Vertical carto (implies stereo)
2 = Vertical reconnaissance
3 = Other

CLOUD COVER (Percentage of quad)

0 = 0% 5 = 50%
1 = 10% 6 = 60%
2 = 20% 7 = 70%
3 = 30% 8 = 80%
4 = 40% 9 = 90%

CAM SPEC (Camera Specifications)

Indicates if camera meets USGS calibration specifications.

Y = Yes
N = No
Blank - Unknown

QUAD COVER (Quad Coverage)

1 = 10% 6 = 60%
2 = 20% 7 = 70%
3 = 30% 8 = 80%
4 = 40% 9 = 90%
5 = 50% 0 or blank = 100%

REMARKS

Field for agency use

RECORD NUMBER

Unique identification number for an agency's records.

Figure 12. Sample microfiche listing from APSRS.

The Landsat program is ongoing; new satellites continue to be launched, some with improved resolution power. At present, however, available satellite imagery seldom provides adequate resolution of ground detail for analyzing areas the size of an installation. Resolution of ground detail is expected to improve significantly as new Landsat satellites with improved image recording and sending equipment are launched. Furthermore, some of the unique features of this program, such as the frequency of coverage, the separation of spectral bands, and the relative ease of image acquisition, make this imagery a good source of primary data for certain analyses, such as seasonal changes, reservoir filling, or flood mapping. This program is also a good source of secondary material for analyzing land use, vegetation type, subsurface structures, etc.

NASA High-Altitude Aerial Photography. This program is essentially designed to test remote sensing instruments and techniques. Photographic imagery is obtained at 60,000 ft (18 000 m) or higher in black and white, color, or color infrared, usually on 9 X 9-in. film. Resolution is quite good on this imagery and the original scale (usually approximately 1:120,000) can be enlarged several times while still maintaining good resolution. However, coverage is spotty. A request for a geographic computer search (see sample form in Figure 13) will indicate if there is coverage of a specific site. Search information will also indicate scale, date of acquisition, film type, and image quality. It is also possible for organizations within DOD to request from NASA specific flights to obtain coverage.

Obtaining NASA Imagery. For information about Landsat, other remote sensing NASA programs, ordering information, and lists of available products and prices, contact the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD 57198, phone FTS 784-7151, or commercial 605-594-6511. EROS Data Center also works in coordination with the USGS National Cartographic Information Center in the APSRS system. For information on all available remote sensing coverage (i.e., Landsat, Skylab, NASA aircraft, and aerial mapping photography) of a particular area, request a geographic computer search of the APSRS files, using an inquiry form as shown in Figure 13. These searches can be made for a named area or for an area defined by center or corner geographic coordinates. All available coverage can be obtained from any NASA and/or aerial mapping source, and selection can be limited by source, film type, season, quality, or cloud cover.

A search provides the requester with a computer output which indicates under each requested source type such information as scale, date of acquisition, film type, cloud cover, and image quality. Identification numbers, scene center points, and corner coordinates are assigned to each NASA image. Landsat imagery is identified by a number system of paths and rows.* Aerial mapping photography is obtained along flight lines, and coordinates are given for an entire line or strip of exposures. EROS Data Center will provide further forms and ordering materials and their assistance center will answer specific questions.

Other Information Sources

U.S. Army Waterways Experiment Station

Appendix A of the March 1978 publication, *Guidance for Application of Remote Sensing Environmental Management,*[2] offers a complete listing of remote sensing image products. The listing includes information on the type of film or other sensing material used, the range of scales at which the agency obtains imagery, areas covered, the period and frequency of coverage, as well as information on the types of products available, sizes, enlargements, costs, and procedures for obtaining the imagery. This publication should provide all the information necessary to obtain, if available, whatever imagery a user might need. This appendix is the first in a series of eight designed to assist remote sensing imagery users. Other appendices to be published include:

Appendix B, Sources of New Imagery Missions

Appendix C,† Available Remote Sensing Systems and System Characteristics

Appendix D,† Directory of Remote Sensing Data Analysis Equipment

Appendix E,† Guide to Remote Sensing Training Assistance and Services (Within DOD and Private)

Appendix F,† Mission Planning for Remote Sensing Missions

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*The satellite paths around the earth are numbered and correspond to offset longitudinal coordinate lines. Numbered rows have also been established along latitudinal transets. Reference maps of the United States are available without charge upon request from EROS Data Center at Sioux Falls, SD.

[2]John May, *Guidance for Application of Remote Sensing to Environmental Management*, Appendix A, Instruction Report M-782 (U.S. Army Waterways Experiment Station, March 1978).

†Approximate title.

INQUIRY FORM

GEOGRAPHIC COMPUTER SEARCH

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DATE ____________

NAME MR / MS ____________ (FIRST) ____________ (INITIAL) ____________ (LAST) — ACCOUNT NO (IF KNOWN) ____________

COMPANY ____________ (IF BUSINESS ASSOCIATED) — PHONE (Bus.) ____________

ADDRESS ____________ — PHONE (Home) ____________

CITY ____________ — Your Ref No ____________ (P.O. GOV'T ACCT OR OTHER)

TO INITIATE AN INQUIRY AND COMPUTER GEOSEARCH COMPLETE THE FOLLOWING

POINT SEARCH	POINT #1	POINT #2	POINT #3
LONG / LAT / Selected Point	Latitude ____ ° ____ ' N or S	____ ° ____ ' N or S	____ ° ____ ' N or S
	Longitude ____ ° ____ ' E or W	____ ° ____ ' E or W	____ ° ____ ' E or W
Imagery with any coverage over the selected point will be included	Landsat Only (Worldwide Reference System)		
	Path ____ Row ____ / Path ____ Row ____	Path ____ Row ____ / Path ____ Row ____	Path ____ Row ____

AREA RECTANGLE	AREA #1	AREA #2	AREA #3
LONG / LONG / LAT / LAT	Lat ____ ° ____ ' N or S to	Lat ____ ° ____ ' N or S to	Lat ____ ° ____ ' N or S to
	Lat ____ ° ____ ' N or S	Lat ____ ° ____ ' N or S	Lat ____ ° ____ ' N or S
Imagery with any coverage over the selected area will be included	Long ____ ° ____ ' E or W to	Long ____ ° ____ ' E or W to	Long ____ ° ____ ' E or W to
	Long ____ ° ____ ' E or W	Long ____ ° ____ ' E or W	Long ____ ° ____ ' E or W

If the above geographic coordinates cannot be supplied, please specify area by GEOGRAPHIC NAME AND LOCATION (include a map if possible)

PREFERRED TYPE OF COVERAGE

	Black & White	Color or Color Infrared
☐ Landsat	☐	☐
☐ Skylab	☐	☐
☐ Nasa Aircraft	☐	☐
☐ Aerial Mapping Photography (Minimum color available)		

PREFERRED TIME OF YEAR

Check maximum of three

- ☐ JAN-MAR
- ☐ APR-JUNE
- ☐ JULY-SEPT
- ☐ OCT-DEC
- ☐ All coverage
- ☐ Latest coverage
- ☐ SPECIFIC DATES ____________

NOTE: Seasonal coverage normally applies only to Landsat coverage

MINIMUM QUALITY RATING ACCEPTABLE

☐ 0-2 (VERY POOR) ☐ 3-4 (POOR) ☐ 5-6 (FAIR) ☐ 7-9 (GOOD)

MAXIMUM CLOUD COVER ACCEPTABLE

☐ 10% ☐ 30% ☐ 50% ☐ 80% ☐ 100%

NOTE: Classification of percent of cloud cover is subjective and is relative to the amount of clouds appearing on the imagery and not to their location

APPLICATION AND INTENDED USE ____________

FORM 9-1936 (Jan 1977)

Return completed form to the facility nearest you.

NCIC HEADQUARTERS
U.S. Geological Survey
507 National Center
Reston, VA 22092
FTS: 928-6045
COMM: 703-860-6045

EROS APPLICATIONS FACILITY
NSTL
U.S. Geological Survey
Bay St. Louis, MS 39520
FTS: 494-3541
COMM: 688-3472

NCIC MID-CONTINENT
U.S. Geological Survey
1400 Independence Rd.
Rolla, MO 65401
FTS: 276-9107
COMM: 314-364-3680

EROS DATA CENTER
U.S. Geological Survey
Sioux Falls, SD 57198
FTS: 784-7151
COMM: 605-594-6511

NCIC ROCKY MOUNTAIN
U.S. Geological Survey
Stop 510, Box 25046
Denver Federal Ctr.
Denver, CO 80225
FTS: 234-2326
COMM: 303-234-2326

NCIC WESTERN
U.S. Geological Survey
345 Middlefield Rd.
Menlo Park, CA 94025
FTS: 467-2427
COMM: 415-323-8111

Figure 13. Example inquiry form, Geographic Computer Search.

Appendix G,* Example of a Detailed Mission Management Plan

Appendix H,* Directory of Army Remote Sensing Users.

General Highway Maps

General highway maps are produced by state agencies, usually by the State Department of Transportation or the State Highway Commission, to provide detailed information on the location of transportation routes, road surface types, and other cultural features of the landscape.

Description. Since these maps are produced at the state level, the types of information represented and the method of representation varies from state to state. Thus there may be exceptions to the following general description. Besides illustrating all national and state highways, county roads, and railroads, most general highway maps also include section lines, township, range, and section numbers, plus cultural information such as rural buildings and facilities (i.e., parks and hospitals), engineering structures (i.e., bridges, towers, dams), mining and industrial sites, and airports and airfields. Some of the larger-scale maps are quite detailed and may provide 10 to 20 different road surface categories (e.g., primitive, graded and drained, gravel or stone, or bituminous) as well as many other road details, such as bridge types and crossing types. Also, some states publish maps with drainage and topographic information. Highway maps are usually monocolor line maps, although sometimes they may have color options (e.g., black for cultural features and blue for drainage) for an increased price.

Scales. Highway maps are often available for both cities and counties at several different scales and sheet sizes varying from very large-scale, large-sheet maps, 1:10,000 or larger, to full county maps on 8 1/2 X 11-in. sheets with scales of 1:250,000 or smaller. Commonly used are 1/8 in. to 1 mile (1:7,920), 1/4 in. to 1 mile (1:15,840), 1/2 in. to 1 mile (1:31,680), 1 in. to 1 mile (1:63,360), 1 in. to 2 miles (1:126,720), and 1 in. to 4 miles (1:253,440).

Significance for Army Use. General highway maps are more frequently updated and usually provide more detailed information on roads and railroads than topographic maps. Thus, these maps provide primary sources of information for transportation planning and analysis. When drainage and/or contours are included, these maps may be used to supplement USGS and DMA topographic maps for a variety of other analysis purposes. Furthermore, because highway maps are usually available at multiple scales and include section lines for referencing, they can provide a base map for plotting information from other sources, such as subsurface features from drillers' oil well logs, or land use features from aerial photographs. Occasionally, however, special problems occur for military users when installation information is omitted. For example, detailed maps produced by the State Highway Commission of Kansas, Department of Planning and Development, omitted roads and other information from the Fort Riley military reservation grounds.

Obtaining Highway Maps. There is no compiled list of addresses and points of contact for the various highway map publishing agencies in each of the 50 states. However, CERL Technical Report N-40[3] provides a list of personnel, addresses, and phone numbers for a relevant state transportation office. This contact will usually be within the same agency that publishes maps and will likely be able to direct inquiries to the appropriate office. Highway maps are generally inexpensive to purchase, ranging from approximately \$.10 to \$2.50 per sheet.

USGS Land Use, Land Cover, and Associated Maps

Since FY75, the USGS Geography Program has been compiling and producing land use maps on the 1:250,000 topographic series scale and format. The maps are intended to provide for consistency in level of detail and for standardization of categories and will eventually be available for the entire United States. A land use classification system was developed by a committee of representatives from USGS, NASA, SCS, Association of American Geographers, and the International Geographic Union. Geological Survey Professional Paper 964, available from the USGS Branch of Distribution Offices, explains this system and each category in detail. The maps are compiled primarily from aerial photographs and other remote sensing data, and secondarily from existing land use maps. Some field checking is done by the Geography Program after compilation in order to insure accuracy of category designation.

*Approximate title.

[3]R. Lacey, H. Balbach, and J. Fittipaldi, *Compendium of Administrators of Land Use and Related Programs*, Technical Report N-40/ADA057226 (U.S. Army Construction Engineering Research Laboratory, July 1978).

The minimum number of mapping units on the 1:250,000 series is 10 acres for urban areas and 40 acres for most non-urban areas. This is too generalized a scale for most military installation uses. Some land use mapping is being done in areas where topographic or planimetric mapping has been completed at the 1:100,000 level, and information at this scale may be more applicable to installation use. In addition to land use mapping, there is also a series of associated maps being completed as overlays for the USGS 1:250,000 quadrangle maps; these include political units (county and state boundaries), hydrologic units (major watersheds as established by the Water Resources Council), census and county subdivisions, and Federal land ownership (40-acre minimum size indicated).

All of the maps discussed above can be obtained from any USGS NCIC Office or Branch of Distribution Office. The maps can be ordered as (1) stable base film positives (clear or matte), (2) semi-stable diazo foil (matte), or (3) paper-diazo. Figure 14 indicates the status of the 1:250,000 series mapping program as of September 1976. Current status maps can be obtained from the USGS Branch of Distribution Offices.

Orthophotos

Orthophotos are composed of several aerial mapping photographs reproduced as a single image at a uniform scale and in true planimetric position. As discussed previously, all aerial photographs have some distortion because of differences in ground elevation and the tilt of the recording camera. When continuous overlapping aerial photographs are put together to form a mosaic image of an area, there is an imperfect fit. In assembling these mosaics, adjoining photographs can be visually matched (uncontrolled mosaic) to reduce a visual distortion, or known features can be accurately positioned by measurement (controlled or semi-controlled mosaic) to provide for reasonably accurate quantitative analysis. However, by using corrective photogrammetric equipment and consecutive overlapping photographs (stereo pairs), horizontal ground surface distortion can be virtually eliminated, as with orthophotos.

USGS Orthophoto Products. USGS orthophotos are sometimes considered interim materials because they can be completed much more quickly than the line work for maps. While a large-scale topographic map may require 3 or more years from the time the aerial photographs are obtained until the full-color line map is printed, orthophotos of the same area may be available within 1 year of the photo acquisition date. For example, prototype metric 1:25,000 orthophotoquads and topographic maps were produced by USGS for the Saranac Lake, New York region. The photographic imagery was obtained 13 May 1976. The orthophotoquad for the area was published later in 1976, and the topographic map was not published until mid-1978.

The standard USGS orthophoto product is the orthophotoquad, which usually corresponds in scale and format to either the 7.5-minute or the 15-minute topographic quadrangles. These quads are often generated for areas where existing large-scale topographic maps are outdated, and new material is needed as soon as possible. These orthophotoquads may never be published, but rather be available as advance copies from the appropriate USGS regional NCIC office. At a user's request, the NCIC office will make an ozalid orthophotoquad copy from an original negative. Currently, only about 10 percent of the orthophotoquads are actually published, however, USGS is considering publishing orthophotoquads on the back of topographic maps. The Army Map Service, a predecessor of the Defense Mapping Agency, at one time did publish pictomaps on the backs of their topographic maps. These pictomaps are roughly equivalent to orthophotoquads, but they are not as free of distortion. In the margin of the prototype 7.5-minute by 15-minute orthophotoquad for Saranac Lake, USGS has published the following description of their orthophotoquad mapping program.

> "As part of the national mapping program, the Geological Survey produces, in addition to standard topographic maps, a series of orthophotoquads covering selected areas of the United States.
>
> An orthophotoquad is either a quadrangle-centered orthophotograph or orthophotograph mosaiked in a quadrangle format with minimum cartographic enhancement. The photo imagery is corrected within specified geometric limits and meets the same positional accuracy requirements as a topographic map.
>
> Reproduced in black and white, orthophotoquads are designed to serve as interim map substitutes for an unmapped area or as a complement to an existing topographic map."

Orthophotographs are mono-color and produced with minimum cartographic enhancement. They are more difficult for most map users to read than topographic maps, and they do not provide relief or

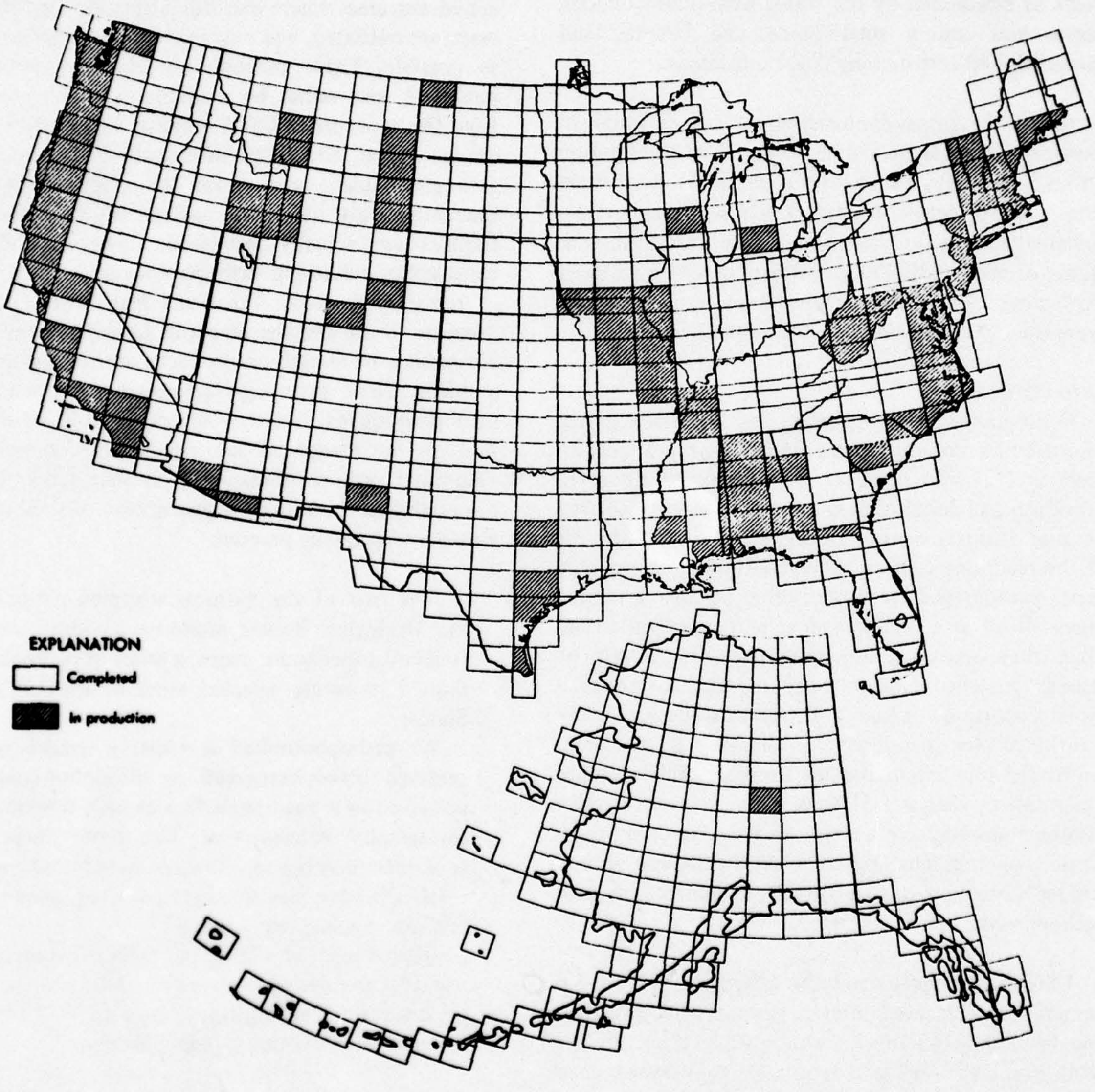

Figure 14. Status of USGS 1:250,000 land use and land cover mapping as of September 1976. (From *USGS Annual Report,* Figure 68 [USGS, 1977].)

vertical information. Enhancement on the Saranac Lake map simply involved the overprinting of a UTM grid and the identification of some ponds, lakes, and a few selected cultural features. By photoreproducing the land surface, however, the orthophotoquads do indicate some natural features, such as tree or shrub density and coverage, more accurately than do topographic maps.

Orthophoto Maps. Orthophoto maps are cartographically enhanced orthophoto products. There are no set criteria for the type of enhancement, but they are usually printed in several colors. Some of these maps have relief contours and spot elevations, and most are overprinted with a variety of cultural enhancements such as section lines and numbers. Transportation routes which may be obscured by vegetation on unenhanced imagery are also enhanced. Orthophoto maps have only been produced for a few scattered areas of the United States. They are most effective in flat or swampy areas where it is difficult to indicate landscape features with common topographic map symbols.

Obtaining Orthophoto Materials. USGS periodically publishes and distributes, free of charge upon request, a national index sheet, "Status of Orthophotoquad Mapping." This index sheet indicates, by symbol, four active categories within a 7.5-minute quadrangle unit. Category 1 is quad areas for which photo acquisition is planned. Category 2 is quad areas for which high altitude quadphoto imagery has been obtained. Category 3 is quad areas for which advanced orthophotoquad maps are available. Category 4 is quad areas for which actual published orthophotoquads or orthophoto maps are available. Orders and inquiries are directed to the appropriate regional NCIC office, as listed in Table 2.

Several other Government and commercial agencies produce orthophoto products, including the Bureau of Reclamation, the Tennessee Valley Authority, and the U.S. Soil Conservation Service. A one-page section entitled "Photo Mapping" of the Geological Survey's 1970 National Atlas briefly discusses orthophoto products, and provides comparative examples from a topographic map, an orthophotoquad map, and an orthophoto map. In addition, the National Atlas includes a status map, which indicates areas where orthophoto materials are available from various commercial firms and government agencies as of September 1967.

General Sources of Map Information

USGS is the major civilian mapping agency in the United States, producing many of the maps discussed in this report (i.e., topographic maps, hydrologic maps, geologic maps, land use maps, orthophoto maps, and the National Atlas). The USGS National Cartographic Information Centers (NCIC) are intended to provide map and imagery users with information on both USGS and non-USGS mapping activities. Currently, NCIC has only limited information on non-USGS mapping programs. However, in the future, NCIC may be able to provide current user information on all national mapping activities. A free pamphlet available from USGS, entitled *Types of Maps Published by Government Agencies,* summarizes several dozen Federal Government mapping products according to type, producing agency, and distribution agency. This pamphlet also lists addresses for each involved agency. Another free pamphlet published by USGS, *Selected Bibliography on Maps and Mapping,* lists by title, author, publisher, and date, several dozen publications related to the use and construction of maps.

Other USGS publications that provide general map information are annual reports and the National Atlas.

USGS Annual Reports

The annual *USGS Report* summarizes each year's mapping and other activities, discusses directions in mapping programs, and summarizes state-of-the-art cartographic techniques. Also included are status maps; some indicate current investigation and mapping sites, and others indicate the most recent status of published maps for the various USGS mapping programs. Information is provided about the USGS organizational structure and offices, and a listing of the many Federal, state, and local cooperating agencies is given. Copies of these reports can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, or from the USGS Branch of Distribution Office in Arlington, VA (Table 1).

National Atlas

The *National Atlas of the United States of America,* prepared and published by the USGS, is a valuable and comprehensive document containing hundreds of maps, as well as associated text on biophysical and socioeconomic topics. The first printing (1970) is a large-format, bound document more than 400 pages long. This edition is now out of stock, although some individual maps are still available from the USGS Branch of Distribution Offices, and copies are available

at most libraries. A second edition will be printed in 1980.

Map scales employed in the atlas are, with minor exceptions, standardized. The multi-paged general reference maps of regional portions of all 50 states are at a scale of 1:2,000,000. Featured urban areas are at a scale of 1:500,000, and the various thematic maps are at scales of 1:7,500,000, 1:17,000,000, and 1:34,000,000. Of special interest to environmental planners and analysts at the installation level are the 1:7,500,000 scale biophysical maps listed below.

Map Title	*Page No.*
Shaded Relief	56-7
Classes of Land Surface Forms	62-3
Major Recorded Earthquakes	66-7
Tectonic Features	71
Geology	74-5
Coastal Land Forms	78-9
Distribution of Principal Kinds of Soil Orders, Suborders, and Great Groups	86-7
Natural Vegetation	90-1
Average Annual Runoff and Large Surface Reservoirs	118-9
Productive Aquifers and Withdrawal From Wells	122-3
Principal Uses of Water	126-7
Major Land Uses	158-9

Numerous other maps at the 1:17,000,000 and 1:34,000,000 scales may be useful for various purposes. For example, isoline seasonal maps of heating degree days, frost-free days, or langleys of solar radiation may provide a necessary figure to complete an analysis equation if the user simply plots the location of an installation in the appropriate delineated area. However, these maps are usually at such a small scale that they can provide only reference data to compare with larger-scale maps and photos. Where information is needed about vegetation, soils, geology, or land use, and no large-scale maps are available, it is best to refer to statewide maps having a scale of 1:500,000 or 1:1,000,000, rather than the 1:7,500,000 or smaller-scale maps contained in the National Atlas. This is because the level of detail and accuracy that can be illustrated while maintaining visual clarity on a map is drastically reduced as scale is reduced.

The National Atlas, besides providing a comprehensive range of small-scale biophysical and socioeconomic maps, offers several other useful features. It contains maps indicating county boundaries, standard metropolitan statistical area boundaries, and the regional boundaries of several dozen Federal agencies. Pages 295-328 are of particular interest to environmental planners and analysts, offering information on source material. This section summarizes all Federal mapping and charting activities and provides status maps, sample illustrations, textual explanations, and ordering information for the following types of source materials:

1. Coast, harbor, intercoastal waterways, and other navigational charts
2. Various aeronautical charts
3. Standard topographic maps, special topographic maps, and state-base maps
4. National forest maps
5. Land survey records
6. Geodetic control diagrams
7. Orthophoto maps, orthophotomosaics, and aerial mosaics
8. Aerial photographs
9. Geologic maps
10. Soil surveys
11. Hydrologic maps.

While some of the status maps in the 1970 atlas are now dated, this material is still very useful, and consulting the National Atlas should be one of the primary steps in assembling source materials.

3 CONSIDERATIONS IN THE USE OF EXISTING SOURCES AS ANALYTICAL TOOLS

This chapter discusses four elements peculiar to maps and photographs which must be considered when using graphic tools for quantitative analysis: scale, conversions, slope, and area measurements.

Scale

Scale is the numeric factor that relates maps and photographs and other remotely sensed images to the landscape, i.e., the relationship between distance on a map or image and the corresponding distance on the earth's surface. Further, the degree of detail that can be clearly presented on a map or the degree of ground

detail that can be discerned on an image is a function of scale. Thus, scale is a primary consideration in preparing a map, planning a remote sensing mission, and in selecting the most appropriate materials for analysis purposes.

The scale of a map or image implies the degree to which ground detail is simplified or generalized. The smaller the scale, the more ground detail that is omitted from a map and the more ground detail that becomes indiscernable on an image. Both the size of the area and the type of subject to be depicted on a map or image are important factors to consider in selecting scale.

Expressing Scale

Scale can be indicated by either a graphic scale or an arithmetic scale, such as a representative fraction (RF). Graphic scales are bars or lines calibrated to indicate a specific map distance and labeled on the map to indicate the corresponding ground distance. If it is necessary to enlarge or reduce a map, the graphic scale is more advantageous than the RF scale since it can change in the same ratio as the map; the RF scale must be recalculated with each enlargement or reduction.

RF scales express ratios of units on the map to units on the ground; thus, 1:100,000 indicates that one map inch equals 100,000 ground inches, or one map centimeter equals 100,000 ground centimeters. RF scales are called unitless expressions, since they avoid the need for conversion factors between measurement systems. Map series are sometimes produced at RF scales that convert to a convenient unit within a measuring system; examples include the USGS 1:24,000 topographic series on which one map inch equals 2,000 ground feet, or the USGS 1:63,360 series (which is sometimes employed rather than the 1:62,500) on which one map inch equals one ground mile. However, most RF scales do not conveniently convert to ground units, and considerable calculation is necessary to convert numerical information from one unit to another or to compare distances between maps constructed at different scales. These calculations are discussed in the *Conversions* section of this chapter. Identifying a scale, such as 1:63,360, as 1 inch to 1 mile is sometimes referred to as a "verbal scale," because this is commonly done when orally relating map proportions. Figure 15, excerpted from a USGS state of Oklahoma map, illustrates three different methods of indicating scale, the representative fraction, the verbal scale and the graph or bar scale.

Frequently, the terms "large scale" and "small scale" are confused. This confusion usually results from an inverse relationship of scale to area. That is, the larger the scale of a map or image, the smaller the area of the earth's surface represented, given that the map or image size remains constant. One way to help clarify this is to represent scale as a fraction, with the

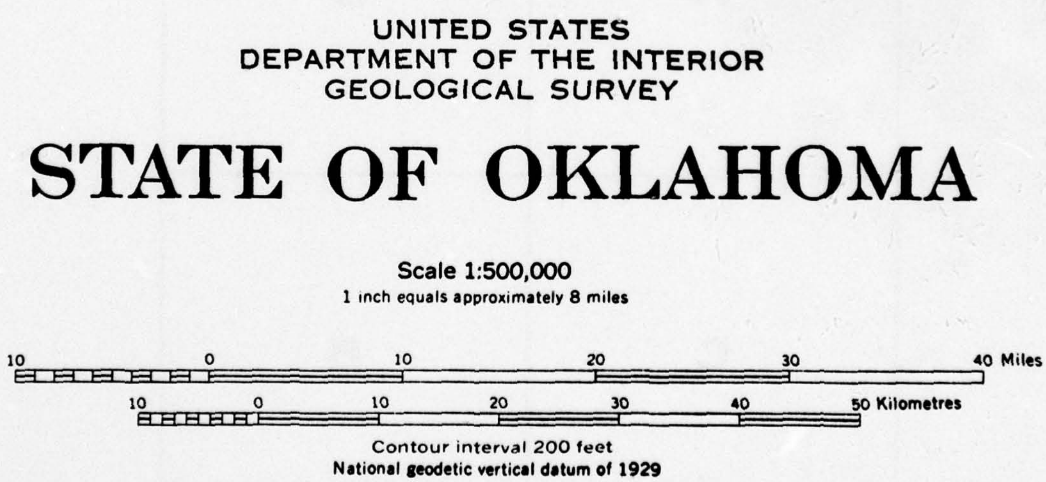

Figure 15. Scale expressions excerpted from a USGS State topographic map. In this map series, scale is given as a representative fraction (1:500,000); as a verbal scale (1 in. equals approximately 8 miles); and as a graphic or bar scale in both kilometers and miles.

numerator as one unit of length (inches or millimeters) on the map, and the denominator as the corresponding number of units on the ground. Thus, 1:5000 is stated as 1/5000. If the denominator is reduced by one-half, to 1/2500, then the scale is twice as large, and the area of the earth's surface represented on an equal size map or image will be reduced to one-fourth of that represented at the 1/5000 scale. In Figure 16, a square map measures 10 cm on each side and 100 cm in area. At a scale of 1/5000, the area of ground represented is 500 m on each side or 250 000 m^2. If the scale is reduced to 1/2500, then the ground distance is 250 m on each side and the area is 62 500 m^2, one-fourth of 250 000 m^2. Further, each of the four quadrants A thru D at the 1/5000 scale represents 62 500 m^2 in a map area of only 25.0 cm^2. At the 1/2500 scale, a map area of 100 cm^2 is required to represent the same 62 500 m^2 ground area.

Imagery Scales

Remotely sensed imagery can present particular problems in determining scale. RF or bar scales are seldom indicated either marginally or directly on the image, although an RF scale is frequently given when the images are ordered. However, if the scale is not known for an image but a map with the known scale is available for the same area, scale can be determined by comparing map and image distance between two known points. For example, if the map scale is 1:24,000 and the distance between the two known objects is 2 in. on the map and 3 in. on the image, then the image scale is determined by multiplying 2/3 X x/24,000. Thus $x = 16{,}000$ and the image scale is 1:16,000.

Scale in aerial photographs is a function of the focal length of the camera lens over the altitude of the aircraft at the time of the exposures, assuming the ground surface is a flat plain and the camera is held perpendicular to the ground. If the ground is not flat, the image scale changes as the ground rises and falls. And if the image recording equipment is not exactly perpendicular to the ground, the scale is distorted from one site to another within the image, according to the degree of shift from the perpendicular. These problems of scale

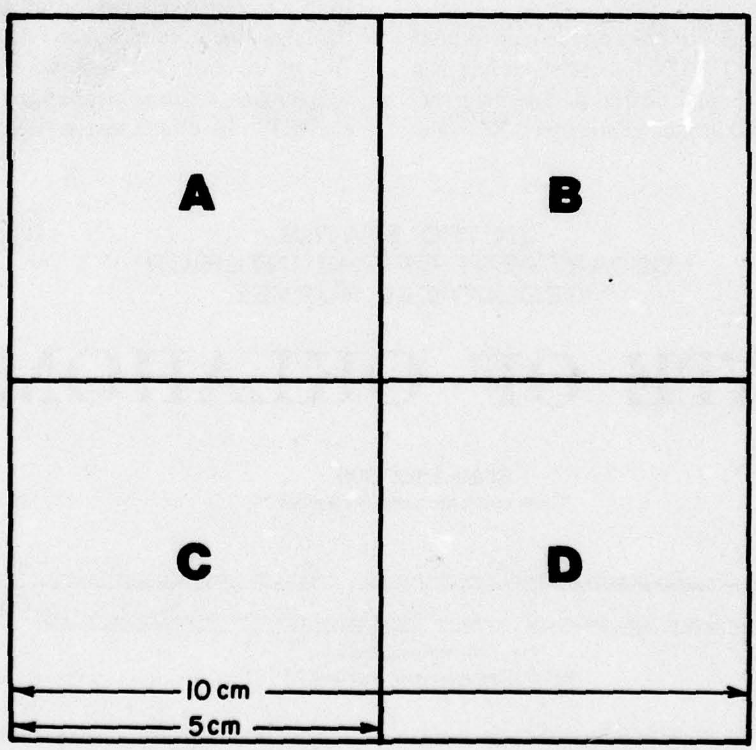

Figure 16. Scale and area.

changes within an image decrease as the altitude of the image sensor increases and the recording scale decreases.

Scales on aerial photographs can be readily changed by enlarging transparencies. Using this technique, ground detail recorded at high altitudes (small scales) can be observed as if it were recorded at low altitudes (large scales) up to the point at which this detail becomes too fuzzy or unresolved to discern. Therefore, high-resolution image-recording equipment provides the advantage of recording large areas (the higher the altitude, the larger the area) in a single frame which can then be observed at both the recording scale and at enlarged scales. Much of the standard black and white aerial photographic imagery that was previously recorded at the 1:20,000 scale is now recorded at the 1:40,000 scale with the use of high-resolution photographic lenses; this results in both lower acquisition cost and improved scale reliability.

Conversions

Environmental analysis usually involves integrating information from several sources. For example, analysis of potential erosion from a clear-cut site requires information on vegetation cover; soil permeability, composition, and structure; slope length and degree; and distance to receiving waters. Calculating erosion potential may therefore require, if available, a soil series map, a topographic map, a vegetation map, and perhaps aerial photographs. The scales of these sources will probably be different; e.g., the soil map, 1:15,600; the topographic map, 1:24,000; the vegetation map, 1:125,000; and the aerial photograph, 1:20,000. Extensive conversions would therefore be necessary to use these different sources to describe one site accurately. Table 3 provides conversion factors for the most frequently used representative fractions. Using this table and the above example, a site of 1000 sq ft (92.89 m^2) would occupy on the soil survey (1:15,600), .59 sq in. (3.81 cm^2); on the aerial photograph (1:20,000), 0.36 sq in. (2.32 cm^2); on the topographic map (1:24,000), 0.25 sq in. (1.60 cm^2); and on the vegetation map (1:125,000), .009 sq in. (0.59 cm^2). To establish common dimensions for all of these source materials at the largest scale (1:15,600) would require graphically enlarging or mathematically multiplying the measured area as follows: for the aerial photograph, 1.639 times; for the topographic map, 2.360 times; and for the vegetation map, 65.556 times. In this case, the vegetation map would probably be at too small a scale for accurate comparison; however, vegetation information could also be determined from the aerial photographs, by on-site inspection, or by visual interpretation of the available map. Area measurements and some methods of accomplishing area conversions, both graphically and mathematically, are discussed later in this chapter.

Using maps and imagery for environmental analysis also frequently requires conversion from one unit to another (e.g., feet to inches) or from one system to another (e.g., inches to centimeters). Table 4 can assist map users with such conversions. The following equation for using these tables is quite simple. Divide the ground portion of a map's representative fraction scale (i.e., 62,500 for 15-minute topographic maps) by the conversion factor given in the table for the conversion desired. Thus, to convert from meters to feet, 62,500 is divided by 0.30480. The result is 205,052.49. Therefore, 1 map meter equals 62,500 ground meters or 1 map centimeter equals 625 ground meters, is converted to 1 map meter equals 205,052.49 ground feet or 1 map centimeter equals 2,050.5249 ground feet.

Slope

Slope refers to the degree to which a given stretch of land is inclined away from the horizontal. The terrain surface is a mosaic of varying slopes, and slope is a primary factor in several landscape processes, such as erosion, landslides, and the establishment of soil and vegetation (the steeper the slope, the less soil and vegetation are able to become established).

Although slope information is basic for landscape analysis, there are no general sources of slope maps, since they have been prepared for only a few scattered sites in the United States. In recent years, there has been considerable experimentation with generating slope maps by automated processes. The techniques require some hardware components such as digitizers and line plotters and are often difficult and time-consuming to initiate, but they do produce several types of useful map products which can be easily altered or updated. The U.S. Army Engineer Waterways Experiment Station's Technical Report M-77-3, *An Automated Procedure for Slope Map Construction,* provides an analysis and presentation of such techniques. The USDA Forest Service has also developed automated slope mapping techniques, and now has two operational systems: (1) TOPAS (Topographic Analysis System), and (2) VIEW-IT. Information can be obtained on TOPAS from the USDA Forest Service, Washington, DC 20250, and on VIEW-IT from the USDA Forest Service, Pacific Southwest Range and Experimentation Station, Berkeley, CA. CERL Interim

Table 3
Conversion Factors for Representative Fractions
(From *Agriculture Handbook 294,* U.S. Department of Agriculture, 1966.)

Ratio scale	Feet per inch	Inches per 1000 feet	Inches per mile	Miles per inch	Meters per inch
1: 500	41.667	24.00	126.72	0.008	12.700
1: 600	50.00	20.00	105.60	0.009	15.240
1: 1,000	83.333	12.00	63.36	0.016	25.400
1: 1,200	100.00	10.00	52.80	0.019	30.480
1: 1,500	125.00	8.00	42.24	0.024	38.100
1: 2,000	166.667	6.00	31.68	0.032	50.800
1: 2,400	200.00	5.00	26.40	0.038	60.960
1: 2,500	208.333	4.80	25.344	0.039	63.500
1: 3,000	250.00	4.00	21.12	0.047	76.200
1: 3,600	300.00	3.333	17.60	0.057	91.440
1: 4,000	333.333	3.00	15.84	0.063	101.600
1: 4,800	400.00	2.50	13.20	0.076	121.920
1: 5,000	416.667	2.40	12.672	0.079	127.000
1: 6,000	500.00	2.00	10.56	0.095	152.400
1: 7,000	583.333	1.714	9.051	0.110	177.800
1: 7,200	600.00	1.667	8.80	0.114	182.880
1: 7,920	660.00	1.515	8.00	0.125	201.168
1: 8,000	666.667	1.500	7.92	0.126	203.200
1: 8,400	700.00	1.429	7.543	0.133	213.360
1: 9,000	750.00	1.333	7.041	0.142	228.600
1: 9,600	800.00	1.250	6.60	0.152	243.840
1: 10,000	833.333	1.200	6.336	0.158	254.000
1: 10,800	900.00	1.111	5.867	0.170	
1: 12,000	1,000.00	1.0	5.280	0.189	304.801
1: 13,200	1,100.00	0.909	4.800	0.208	335.281
1: 14,400	1,200.00	0.833	4.400	0.227	365.761
1: 15,000	1,250.00	0.80	4.224	0.237	281.001
1: 15,600	1,300.00	0.769	4.062	0.246	396.241
1: 15,840	1,320.00	0.758	4.00	0.250	402.337
1: 16,000	1,333.333	0.750	3.96	0.253	406.400
1: 16,800	1,400.00	0.714	3.771	0.265	426.721
1: 18,000	1,500.00	0.667	3.52	0.284	457.201
1: 19,200	1,600.00	0.625	3.30	0.303	487.681
1: 20,000	1,666.667	0.60	3.168	0.316	508.002
1: 20,400	1,700.00	0.588	3.106	0.322	518.161
1: 21,120	1,760.00	0.568	3.00	0.333	536.449
1: 21,600	1,800.00	0.556	2.933	0.341	548.641
1: 22,800	1,900.00	0.526	2.779	0.360	579.121
1: 24,000	2,000.00	0.50	2.640	0.379	609.601
1: 25,000	2,083.333	0.480	2.534	0.395	635.001
1: 31,680	2,640.00	0.379	2.000	0.500	804.674
1: 48,000	4,000.00	0.250	1.320	0.758	1,219.202
1: 62,500	5,208.333	0.192	1.014	0.986	1,587.503
1: 63,360	5,280.00	0.189	1.000	1.000	1,609.347
1: 96,000	8,000.00	0.125	0.660	1.515	2,438.405
1: 125,000	10,416.667	0.096	0.507	1.973	3,175.006
1: 126,720	10,560.00	0.095	0.500	2.00	3,218.694
1: 250,000	20,833.333	0.048	0.253	3.946	6,350.012
1: 253,400	21,120.00	0.047	0.250	4.00	6,437.389
1: 500,000	41,666.667	0.024	0.127	7.891	12,700.025
1: 1,000,000	83,333.333	0.012	0.063	15.783	25,400.050

(SOURCE: U.S. Department of Agriculture, *Agriculture Handbook*, 294, 1966.)

Table 4
Conversion Factors for Linear Units
(From William Marsh, *Environmental Analysis for Land Use and Site Planning* [McGraw-Hill, 1978])

The conversion factor is the number in the table. Divide the conversion factor into the "from" unit to obtain the "to" unit. For example, 1 yard to feet = 1/0.33 = 3.0 feet.

To ↓ / From →	Centimeter	Inch	Link	Foot	Vara (California)	Vara (Texas)	Yard	Meter	Rod, Pole or perch	Chain	Furlong	Kilometer	Mile (statute)
Centimeter	1	0.3937	0.049710	0.032808	0.011930	0.011811	0.010936	0.01	0.001968				
Inch	2.54001	1	0.12626	0.08333	0.03030	0.03	0.02778	0.02540	0.00505	0.00126			
Link	20.1168	7.92	1	0.66	0.24	0.2376	0.22	0.20117	0.04	0.01	0.001		
Foot	30.4801	12	1.51515	1	0.36364	0.36	0.33333	0.30480	0.06061	0.01515	0.00152		
Vara (California)	83.8202	33	4.16667	2.75	1	0.99	0.91667	0.8382	0.16667	0.04167	0.00417		
Vara (Texas)	84.6668	33.333	4.20875	2.77778	1.01010	1	0.92583	0.84667	0.16835	0.04209	0.0042		
Yard	91.4402	36	4.54545	3	1.09091	1.08	1	0.9144	0.18182	0.04545	0.00455		
Meter	100	39.37	4.97096	3.28083	1.19303	1.1811	1.09361	1	0.19884	0.04971	0.00497	0.001	
Rod, pole, or perch	502.921	198	25	16.5	6	5.94	5.5	5.02921	1	.25	.025	.00503	.00313
Chain	1,828.80	792	100	66	24	23.76	22	20.1168	4	1	0.1	0.02012	0.0125
Furlong	20,116.8	7,920	1,000	660	240	237.6	220	201.168	40	10	1	0.20117	0.125
Kilometer	100,000	39,370	4,970.96	3,280.83	1,193.03	1,181.1	1,093.61	1,000	198.838	49.7096	4.97096	1	0.62137
Mile (statute)	160,935	63,360	8,000	5,280	1,920	1,900.8	1,760	1,609.35	320	80	8	1.60935	1

Report N-55, *Data Requirements for Army Land Use Planning and Management,* also discusses and evaluates several automated mapping procedures.

Measuring Slopes From Existing Sources

When no slope map is available for a particular site, information on slopes can be derived from aerial photographs and topographic maps, as well as from field observation and measurement.

Aerial Photographs. In standard aerial mapping photography, each successive film exposure overlaps the previous exposure's ground surface area by about 40 to 50 percent. If successive prints are laid side by side (called stereo pairs) and viewed stereoscopically, they will provide a three-dimensional view of the landscape. The simplest form of steroscopic viewing involves the use of inexpensive plastic or glass lenses which usually have a 2X magnification. The area of ground surfaces depicted on each of the separate photographic prints is viewed from both eyes, or from two perspectives. When the stereoscopic lenses are adjusted to the proper height and position above the prints (this adjustment may differ with each viewer), the viewer's eyes combine the two perspectives and see an optical illusion of a three-dimensional landscape. Landscape relief viewed in this manner is directly proportional to the actual landscape, but the stereoscopic illusion is vertically exaggerated. High points on the landscape, such as hilltops and tall buildings, seem to "pop out" at the viewer.

While slopes can be observed with inexpensive stereoscopic lenses, additional photogrametric equipment is necessary to measure these observed slopes. Parallax bars, which work on the floating dot principle, can be used with simple stereoscopes; however, this will only allow height measurements and not actual determinations of slope along horizontal distances. Devices for measuring actual slopes include the slope-measuring parallax wedge, which uses fused floating lines to determine slope angle, and the stereo slope meter, which uses fused concentric circles to measure slope percent. For more detailed information on these instruments and measuring techniques, consult The American Society of Photogrametry's *Manual of Photogrametry,* published in 1966. While it is possible to derive quantitative slope information from aerial photographs, the accuracy depends on the skill of the user, the quality of the imagery, and the reliability of the instrumentation. USGS and DMA determine topographic contours from stereopairs, but use highly sophisticated equipment, skilled personnel, and the best possible imagery.

Topographic Maps. If the site for which slope information is required has been mapped by reliable, large-scale topographic maps, as is true for most U.S. Army installations, then topographic maps are the recommended source from which to determine slope. Quantitative slope information can be obtained readily by measuring the intervals between contour lines, which provide both graphical and numerical representations of land surface configurations. The distance between adjoining contour lines can be calibrated to degree of slope, percent of slope, or a ratio of horizontal to vertical distance (rise to run). Both contour interval and map scale must be considered in determining slope. Essentially, the closer the contour lines are on the map, the steeper the slope.

Norman Thrower and Ronald Cooke[4] constructed calibrated scales for use with each of the standard USGS large-scale topographic maps (1:24,000 and 1:62,500). These scales are shown in Figures 17 and 18. Thrower and Cooke published the following use instructions:

> "To use the indicator, one simply places the divided edge of the appropriate scale on the map down the slope as suggested by the contours, noting the contour interval. One then moves the scale in order to match, as closely as possible, the spacing of the lines of the indicator with those of the contours. The percentage of slope, the degree of slope, and the slope in feet per mile can then be read directly. By the use of the scales, the measurement of slopes from topographic maps can be accomplished with a minimum of difficulty."

Thrower and Cooke also suggest that to facilitate use, positive transparencies of these scales should be made on stable base film. There are two sheets for each scale; the 1:62,500 scale should be appropriate for 1:63,360 maps, and the 1:24,000 scale can be multiplied by a factor of +1 over 1000 for use with the 1:25,000 scale maps. These scales also provide factors for converting percent to degree, and for converting degree to slope in feet per mile.

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[4]Norman Thrower and Ronald Cooke, "Scales for Determining Slopes from Topographic Maps," *Professional Geographer,* Vol 20, No. 3 (May 1968).

SLOPE INDICATOR Scale 1:24,000

KEY TO CODE

First Number, Percent of Slope; Second, Degrees of Slope; Third, Slope in Feet per Mile.

Contour Interval \ Divisions per Inch	1.0	1.6	2.0	3.0	3.2
5'	.25; 0°08'; 13.2	.40; 0°14'; 21.1	.50; 0°17'; 26.4	.75; 0°26'; 39.6	.80; 0°28'; 42.2
10'	.50; 0°17'; 26.4	.80; 0°28'; 42.2	1.00; 0°34'; 52.8	1.50; 0°52'; 79.2	1.60; 0°55'; 84.5
20'	1.00; 0°34'; 52.8	1.60; 0°55'; 84.5	2.00; 1°09'; 105.6	3.00; 1°43'; 1584	3.20; 1°50'; 169.0
25'	1.25; 0°43'; 66.0	2.00; 1°09'; 105.6	2.50; 1°26'; 132.0	3.75; 2°09'; 198.0	4.00; 2°18'; 211.2
40'	2.00; 1°09'; 105.6	3.20; 1°50'; 169.0	4.00; 2°18'; 211.2	6.00; 3°26'; 316.8	6.40; 3°40'; 338.0
50'	2.50; 1°26'; 132.0	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	7.50; 4°17'; 396.0	8.00; 4°34'; 422.4
100'	5.00; 2°52'; 264.0	8.00; 4°34'; 4224	10.00; 5°43'; 528.0	15.00; 8°32'; 792.0	16.00; 9°05'; 844.8

Contour Interval \ Divisions per Inch	12	15	16	20	24
5'	3.00; 1°43'; 158.4	3.75; 2°09'; 198.0	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	6.00; 3°27'; 316.8
10'	6.00; 3°27'; 316.8	7.50; 4°17'; 396.0	8.00; 4°34'; 4224	10.00; 5°43'; 528.0	12.00; 6°54'; 633.6
20'	12.00; 6°54'; 633.6	15.00; 8°32'; 792.0	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0	24.00; 13°30'; 1267.2
25'	15.00; 8°32'; 792.0	18.75; 10°37'; 990.0	20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0	30.00; 16°42'; 1584.0
40'	24.00; 13°30'; 1267.2	30.00; 16°42'; 1584.0	32.00; 17°45'; 1689.6	40.00; 21°48'; 2112.0	48.00; 25°38'; 2534.4
50'	30.00; 16°42'; 1584.0	37.50; 20°33'; 1980.0	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0	60.00; 30°58'; 3168.0
100'	60.00; 30°58'; 3168.0	75.00; 36°52'; 3960.0	80.00; 38°40'; 4224.0	100.00; 45°00'; 5280.0	120.00; 50°12'; 6336.0

Figure 17. Slope indicator–scale 1:24,000. (From Norman Thrower and Ronald Cooke, "Scales for Determining Slopes From Topographic Maps," *Professional Geographer*, Vol 28, No. 3 (May 1968).

4.0	5.0	6.0	6.4	8.0	10
1.00; 0°34'; 52.8	1.25; 0°43'; 66.0	1.50; 0°52'; 79.2	1.60; 0°55'; 84.5	2.00; 1°09'; 105.6	2.50; 1°26'; 132.0
2.00; 1°09'; 105.6	2.50; 1°26'; 132.0	3.00; 1°43'; 158.4	3.20; 1°50'; 169.0	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0
4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	6.00; 3°26'; 316.8	6.40; 3°40'; 338.0	8.00; 4°34'; 422.4	10.00; 5°43'; 528.0
5.00; 2°52'; 264.0	6.25; 3°34'; 330.0	7.50; 4°17'; 396.0	8.00; 4°34'; 422.4	10.00; 5°43'; 528.0	12.50; 7°08'; 660.0
8.00; 4°34'; 422.4	10.00; 5°43'; 528.0	12.00; 6°54'; 633.6	12.80; 7°18'; 676.0	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0
10.00; 5°45'; 528.0	12.50; 7°08'; 660.0	15.00; 8°32'; 792.0	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0
20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0	30.00; 16°42'; 1584.0	32.00; 17°45'; 1689.6	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0
6.25; 3°34'; 330.0	7.50; 4°17'; 396.0	8.00; 4°34'; 422.4	10.00; 5°43'; 528.0	12.50; 7°08'; 660.0	15.00; 8°32'; 792.0
12.50; 7°08'; 660.0	15.00; 8°32'; 792.0	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0	30.00; 16°42'; 1584.0
25.00; 14°02'; 1320.0	30.00; 16°42'; 1584.0	32.00; 17°45'; 1689.6	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0	60.00; 30°58'; 3168.0
31.25; 17°21'; 1650.0	37.50; 20°33'; 1980.0	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0	62.50; 32°00'; 3300.0	75.00; 36°52'; 3690.0
50.00; 26°34'; 2640.0	60.00; 30°58'; 3168.0	64.00; 32°37'; 3379.0	80.00; 38°40'; 4224.0	100.00; 45°00'; 5820.0	120.00; 50°12'; 6336.0
62.50; 32°00'; 3300.0	75.00; 36°52'; 3960.0	80.00; 38°40'; 4224.0	100.00; 45°00'; 5280.0	125.00; 51°20'; 6600.0	150.00; 56°19'; 7920.0
125.00; 51°20'; 6600.0	150.00; 56°19'; 7920.0	160.00; 58°00'; 8448.0	200.00; 63°26'; 10560.0	250.00; 68°12'; 13200.0	300.00; 71°34'; 15840.0
25	30	32	40	50	60

Figure 17 (con't)

SLOPE INDICATOR Scale 1:62,500

KEY TO CODE

First Number, Percent of Slope; Second, Degrees of Slope; Third, Slope in Feet per Mile.

DIVISIONS PER INCH / CONTOUR INTERVAL	1.04	1.30	2.08	2.60	4.16
5'	.10; 0°03'; 5.3	.13; 0°04'; 6.6	.20; 0°07'; 10.6	.25; 0°09'; 13.2	.40; 0°14'; 21.1
10'	.20; 0°07'; 10.6	.25; 0°09'; 13.2	.40; 0°14'; 21.1	.50; 0°17'; 26.4	.80; 0°28'; 42.2
20'	.40; 0°14'; 21.1	.50; 0°17'; 26.4	.80; 0°28'; 42.2	1.00; 0°34'; 52.8	1.60; 0°55'; 84.5
25'	.50; 0°17'; 26.4	.63; 0°21'; 33.0	1.00; 0°34'; 52.8	1.25; 0°43'; 66.0	2.00; 1.09'; 105.6
40'	.80; 0°28'; 42.2	1.00; 0°34'; 52.8	1.60; 0°55'; 84.5	2.00; 1°09'; 105.6	3.20; 1°50'; 169.0
50'	1.00; 0°34'; 52.8	1.25; 0°43'; 66.0	2.00; 1°09'; 105.6	2.50; 1°26'; 132.0	4.00; 2°18'; 211.2
100'	2.00; 1°09'; 105.6	2.50; 1°26'; 132.0	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	8.00; 4°34'; 422.4
5'	1.50; 0°52'; 79.2	2.00; 1°09'; 105.6	2.50; 1°26'; 132.0	3.00; 1°43'; 158.4	3.75; 2°09'; 198.0
10'	3.00; 1°43'; 158.4	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	6.00; 3°26'; 316.8	7.50; 4°17'; 396.0
20'	6.00; 3°26'; 316.8	8.00; 4°34'; 422.4	10.00; 5°43'; 528.0	12.00; 6°51'; 633.6	15.00; 8°32'; 792.0
25'	7.50; 4°17'; 396.0	10.00; 5°43'; 528.0	12.50; 7°08'; 660.0	15.00; 8°32'; 792.0	18.75; 10°37'; 990.0
40'	12.00; 6°51'; 633.6	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0	24.00; 13°30'; 1267.2	30.00; 16°42'; 1584.0
50'	15.00; 8°32'; 792.0	20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0	30.00; 16°42'; 1584.0	37.50; 20°33'; 1980.0
100'	30.00; 16°42'; 1584.0	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0	60.00; 30°58'; 3168.0	75.00; 36°52'; 3960.0
DIVISIONS PER INCH / CONTOUR INTERVAL	15.6	20.8	26.0	31.2	39.0

Figure 18. Slope indicator–scale 1:62,500. (From Norman Thrower and Ronald Cooke, "Scales for Determining Slopes From Topographic Maps," *Professional Geographer*, Vol 28, No. 3 (May 1968).

5.21	6.51	7.81	8.32	10.4	13.0
.50; 0°17'; 264	.63; 0°21'; 33.0	.75; 0°26'; 39.6	.80; 0°28'; 42.2	1.00; 0°34'; 52.8	1.25; 0°43'; 66.0
1.00; 0°34'; 52.8	1.25; 0°43'; 66.0	1.50; 0°52'; 79.2	1.60; 0°55'; 84.5	2.00; 1°09'; 105.6	2.50; 1°26'; 132.0
2.00; 1°09'; 105.6	2.50; 1°26'; 132.0	3.00; 1°43'; 1584	3.20; 1°50'; 169.0	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0
2.50; 1°26'; 132.0	3.13; 1°47'; 165.0	3.75; 2°09'; 198.0	4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	6.25; 3°34'; 330.0
4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	6.00; 3°26'; 316.8	6.40; 3°40'; 338.0	8.00; 4°34'; 422.4	10.00; 5°43'; 528.0
5.00; 2°52'; 264.0	6.25; 3°34'; 330.0	7.50; 4°17'; 396.0	8.00; 4°34'; 4224	10.00; 5°43'; 528.0	12.50; 7°08'; 660.0
10.00; 5°43'; 528.0	12.50; 7°08'; 660.0	15.00; 8°32'; 792.0	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0	25.00; 14.02'; 1320.0
4.00; 2°18'; 211.2	5.00; 2°52'; 264.0	6.25; 3°34'; 330.0	7.50; 4°17'; 396.0	8.00; 4°34'; 4224	10.00; 5°43'; 528.0
8.00; 4°34'; 4224	10.00; 5°43'; 528.0	12.50; 7°08'; 660.0	15.00; 8°32'; 792.0	16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0
16.00; 9°05'; 844.8	20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0	30.00; 16°42'; 1584.0	32.00; 17°45'; 1689.6	40.00; 21°48'; 2112.0
20.00; 11°19'; 1056.0	25.00; 14°02'; 1320.0	31.25; 17°21'; 1650.0	37.50; 20°33'; 1980.0	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0
32.00; 17°45'; 1689.6	40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0	60.00; 30°58'; 3168.0	64.00; 32°37'; 3379.0	80.00; 38°40'; 4224.0
40.00; 21°48'; 2112.0	50.00; 26°34'; 2640.0	62.50; 32°00'; 3300.0	75.00; 36°52'; 3960.0	80.00; 38°40'; 4224.0	100.00; 45°00'; 5280.0
80.00; 38°40'; 4224.0	100.00; 45°00'; 5280.0	125.00; 51°20'; 6600.0	150.00; 56°19'; 7920.0	160.00; 58.00'; 8448.0	200.00; 63°26'; 10560.0
41.6	52.1	65.1	78.1	83.2	104.5

Figure 18 (con't)

Quantitative Slope Expressions

Slope is expressed by some professions (e.g., planners) in percentage and by others (e.g., civil engineers) in degrees. Percent slope is calculated by dividing slope change in elevation (rise) by the horizontal ground distance (run). This product multiplied by 100 equals percent slope. Thus, a rise in 1 ft (.3 m) in elevation for every 1 ft (.3 m) ground distance is one over one times 100 equals 100 percent. Slope degree is determined by measuring the angle in degrees (out of 360 degrees) that a slope creates in relation to the horizontal surface. A slope that rises 1 ft (.3 m) for every 1 ft (.3 m) of ground distance is 45 degrees; thus, a 100 percent slope equals a 45 degree slope. However, the rate of change between slope percent and slope degree is not arithmetically constant.

For maps at scales other than 1:24,000 and 1:62,500, a simple formula can be used to determine percent slope. For example, on a 1:50,000 scale map with contour intervals of 20 ft (6 m), a user wants to establish slope categories of 5 percent or less, 5 to 10 percent, and greater than 10 percent. The 5 percent slope is calculated as follows:

$5/100 = 20/x \cdot x = 400$. (20/400 is simply a rise-to-run ratio, i.e., a 5 percent slope rises 20 ft [6 m] over a 400-ft [120-m] run.) This 400-ft (120-m) figure can be converted to an interval measurable on the map as follows:

$$\frac{400 \text{ ft} \times 12 \text{ in. per ft}}{50{,}000} = \frac{4800 \times \text{in.}}{50{,}000} =$$

$$\frac{48 \text{ in.}}{500} \sim \frac{50 \text{ in.}}{500} = 1/10 \text{ in.}$$

Thus, when the interval between contour lines measures 1/10 in. (2.5 mm) or more, the slope is 5 percent or less. For 10 percent slopes, the calculation is as follows:

$$10/100 = 20/x \cdot x = 200$$

$$\frac{200 \times 12 \text{ in. per ft}}{50{,}000} = \frac{2400 \text{ in.}}{50{,}000} =$$

$$\frac{24}{500} \approx \frac{25}{500} = 1/20 \text{ in.}$$

Thus, slopes in the category between 5 to 10 percent will measure 1/10 in. to 1/20 in. (2.5 to 1.25 mm) between contour lines. Slopes greater than 10 percent will measure less than 1/20 in. (1.25 mm). If considerable measurement is required, a calibrated scale or transparent, stable material is recommended.

Area Measurement

The measurement of parcels of ground surface areas, as represented on two-dimensional maps, is an important element in planning and analysis procedures. For flat, rectangular sites of known scale, area simply equals length times width times the scale factor. Complications occur when ground surface level is uneven, when the site is non-rectangular, or when the scale is unknown.

Surface Relief in Relation to Area Computation

The greater the amount of relief is at a site, the greater the potential inaccuracy in making area determinations and not adjusting for slope. However, it is relatively simple to make slope adjustments for land surface area measurements from topographic contour maps. Table 5 provides correction factors for slopes of varying rise-to-run ratios (steepness). If slope is known in terms of a degree or percent expression, this expression can be converted to rise-to-run ratio and the proper correction factor obtained from the table.

Table 5
Conversion Factors for Computing Topographic Distance Along a Slope (From William Marsh, *Environmental Analysis for Land Use and Site Planning*, [McGraw-Hill, 1978])

Rise to run ratio	Correction factor
0.10:1	1.0050
0.15:1	1.0112
0.20:1	1.0198
0.25:1	1.0308
0.30:1	1.0440
0.35:1	1.0595
0.40:1	1.0770
0.45:1	1.0966
0.50:1	1.1180
0.55:1	1.1413
0.60:1	1.1662
0.65:1	1.1927
0.70:1	1.2207
0.75:1	1.2500
0.80:1	1.2806
0.85:1	1.3125
0.90:1	1.3454
0.95:1	1.3793
1:1	1.4142

For example, on a 50 percent slope (26 degrees, 34 minutes), the rise-to-run ratio is 0.5 to 1 and the conversion factor from Table 5 is 1.1180. If slope is unknown, the technique shown in Figure 19 can be used to determine rise-to-run ratio. In this illustration, transect lines are run along a specific slope. The elevation from slope bottom (in the illustration, 257 m) to ridge top (340 m) is the rise and the length of the transect line is the run. Marsh explains the calculation as follows:

> "In the case of transect 1, the rise is 83 meters (340-257), and the run is 157.5 meters (this is calculated by measuring the transect using the bar scale). Expressed as a ratio, rise to run is equal to 0.53 to 1. We may now turn to table (5) for the appropriate correction factor for this ratio. Using the closest ratio (0.55 to 1), a correction factor of 1.1413 is given. This factor is multiplied times the run distance to obtain the topographic distance along this transect: 157.5 X 1.1413 = 179.75 meters. This procedure can be repeated for each transect and an average slope length calculated for the slope area. This figure multiplied times the width of the area yields topographic area."[5]

Irregularly Shaped Areas

Area measurements on maps seldom involve regular geometrically shaped areas. For land parcels that are geometric in shape or closely resemble geometric shapes, simple area formulas are adequate to determine land surface area; for example, length times width for rectangles, and height times base divided by 2 for triangles. For land units with curving boundaries and

[5] William Marsh, *Environmental Analysis for Land Use and Site Planning* (McGraw-Hill, 1978).

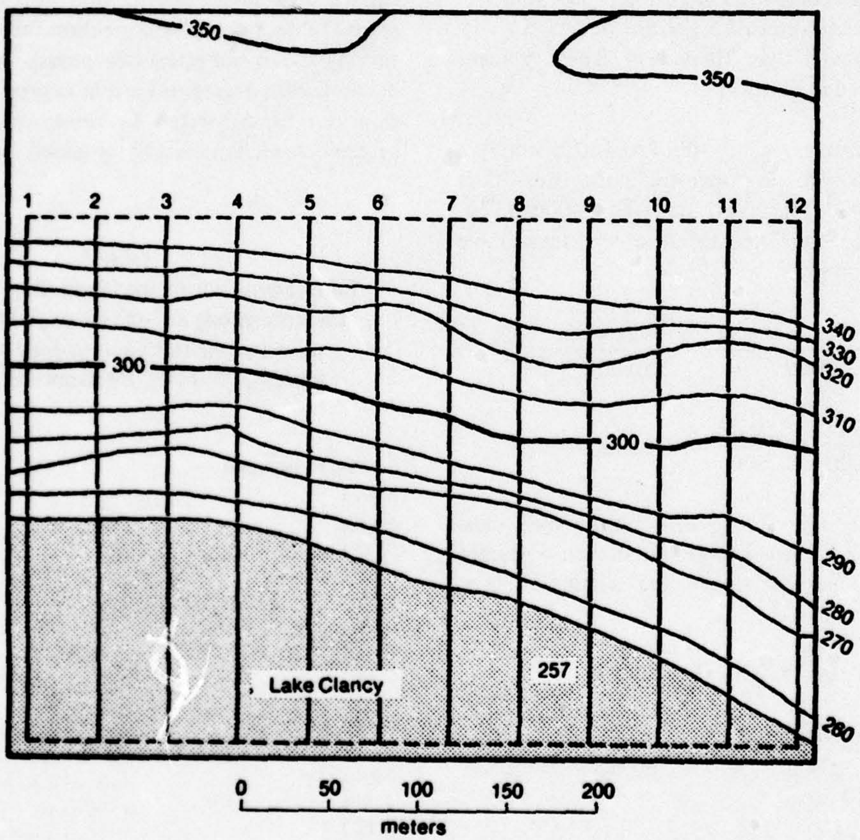

Figure 19. Computation of topographic area (From *Environmental Analysis for Land Use and Site Planning* by William Marsh. Copyright 1978, McGraw-Hill. Used with permission of McGraw-Hill Book Company.)

irregular shapes, either planimeters or grid cells can be used to obtain area measurements.

The planimeter is an instrument specifically designed for measuring areas on maps and aerial photography by tracing circumferences and converting to area units. Generally, however, the square or dot grid method is simpler and quicker. According to the *Manual of Remote Sensing*, "The dot area grid permits area estimates of acceptable accuracy to be made in 1/3 to 1/6 of the time required for planimetering."[6] Grid sheets are commonly available from drafting, engineering, and art suppliers and are printed on either transparent paper or clear film. The grids are calibrated to either English or metric units and are available in a variety of intervals, such as 20 X 20 to the inch, 10 X 10 to the centimeter, or 5 X 5 to the half inch. The use of dots and square grids is essentially the same. Dots are centered in the middle of each square unit that they represent. Grids are placed directly on the map or photograph, and each cell is counted. The land surface value of each cell depends on the image or map scale. For example, using a 20 X 20 cell to the inch grid on a 1:24,000 map in which 1 in. equals 2000 ft, each cell equals 1/20 of the 2000 ft, or 100 sq ft. To calculate the area of a specific parcel, count all the squares or dots falling within that parcel, and assign a partial value to those dots or squares falling on the edge. If, in the above example, there are 475 grid cells within the area and 50 cells along the edge, and if each edge cell is assigned a 1/2 value (50 divided by 2 equals 25 cells), then 475 cells plus 25 cells equals 500 cells. The land surface area of the parcel is then 500 cells times 100 sq ft per cell, or 50,000 sq ft, or 1.148 acres (1 sq ft equals 2.296 times 10^{-5} acres). To avoid tedious counting in larger land parcels, it is advisable to use either widely scattered grid cells and/or grid sheets with index dots or lines. Furthermore, it is possible to measure and calculate much of a land parcel by simple geometry, and then use the grid count method to add the irregular segments.

[6] Robert G. Reeves, *Manual of Remote Sensing*, Vol 2 (American Society of Photogrametry, 1975), p 103.

4 SUMMARY AND RECOMMENDATIONS

This report has described sources of graphic materials useful for quantitative environmental impact analysis. These sources often provide information which would be economically unfeasible to collect and display otherwise. Effective use and interpretation of graphic materials requires consideration of scale, conversions, measurements, and other factors.

It is recommended that Army environmental planners and decision-makers use the information in this report as a reference for sources of graphic materials and information.

APPENDIX A: STATUS OF USGS QUADRANGLE FORMAT MAPS AVAILABLE FOR MAJOR U.S. ARMY INSTALLATIONS

This appendix is compiled from the most recent available USGS topographics series index sheets (1: 1,000,000 scale, 1:250,000 scale) and from the various state index sheets. Since the 1:100,000 series includes only a few scattered areas, none of which contain the major selected U.S. Army installations, it was omitted. The 1:500,000 series is the state boundary series; since published maps are available for each state, this series was also omitted. The county format series is now available only for scattered areas, and land scales change from county to county, so it was also omitted from this appendix.

Installation boundaries were determined whenever possible from the individual map sheets; however, not all map sheets were available at the time this appendix was compiled. Some errors may therefore have been made in selecting the proper quadrangle when an installation boundary occurs near a quadrangle borderline. With the exception of Fort Amador in the Canal Zone and Fort Buchanon in Puerto Rico, the installations selected for this appendix are those located on the Defense Mapping Agency's March 1975 map, "Major U.S. Army Installations FORSCOM/TRADOC."

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
Aberdeen Proving Ground	MD	Harford,	Chesapeake Bay	1955	Baltimore	1857-69	Gunpowder		Aberdeen	1942	
		Baltimore					(incomplete)		Hanesville	1953	
									Gunpowder Neck	1953	
									Perryman	1953	
									Spesutie	1953	
									Edgewood '49 (complete)		
Ft. Belvoir	VA	Fairfax	Chesapeake Bay	1955	Washington	1957-69	Washington		Alexandria	1956-65	
							& vicinity	1956-65	Annandale	1956-65	
							Indianhead	1951-56	Ft. Belvoir	1951-65	
							(incomplete)		Mnt. Vernon	1956-66	
									(complete)		
Ft. Benning	GA	Chattahoochie,	Lookout Mtn.	1968	Phenix City	1955-72	Buena Vista	1947-55	Ft. Benning (HF657)	1947-55	HF 657
		Muscogee					Columbus	1947-55	Buena Vista	1947-55	
							Ellerslie	1947-55	Columbus	1947-55	
							Talbotton	1947-55	Cusseta	1947-55	
							(complete)		Glen Alta	1947-55	
									Midland	1947-55	
									Ochillee	1947-55	
									Upatoi	1947-55	
									(complete)		
Ft. Bliss	TX, NM	El Paso,	Sante Fe	1955	Carlsbad	1954-72	Bassett Lake	1940	Lake Sucero SW	1948	
		Dona Ana	(incomplete)		El Paso	1959-73	Escondido Canyon	1950	Lake Sucero SE	1948	
		Hodspeth			Van Horn	1954-64	Pandejo Wash	1941	Surveyors Canyon	1965	
		Otero					Tres Hermanos	1948	El Paso Canyon	1965	
							(incomplete)		Elwood	1955	
									Nations E. Well	1955	
									Hueco Tanks	1955	
									Ft. Bliss NE	1955	
									Ft. Bliss SE	1955	
									White Sands SE	1955	
									White Sands NE	1955	
									White Sands	1955	
									Davies Tank	1955	
									Oro Grande N	1955	
									Oro Grande S	1955	
									Bishop Cap	1955	
									Organ Peak	1955	
									Anthony	1955	
									Newman	1955	
									Newman NW	1955	
									Newman NE	1955	
									Newman SW	1955	
									Desert SW	1955	
									Desert SE	1955	
									Desert NW	1955	
									El Paso	1955	

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
									N. Franklin	1955	
									Elephant Mtn.	1955	
									Nations Sothwell	1955	
									(incomplete)		
Ft. Bragg	NC	Cumberland	Savannah	1946	Florence	1953-74	Clifdale	1948	Clifdale	1948	
		Hoeke			Raleigh	1953-69	Fayetteville	1948-57	Lobelia	1947-57	
							Southern Pines	1948-57	Manchester	1947-57	
							(complete)		Niagra	1947-57	
									Nicholson Cr.	1948	
									Pine Bluff	1948	
									Over Hills	1947-57	
									Sanatorium	1948	
									(complete)		
Ft. Campbell	KY, TN	Christian	Louisville	1959	Nashville	1956-69	Clarksville	1951-57	Bumpus Mills	1951-57	
		Trigg			Dyersburg	1956-70	Hamdon	1951-57	Herndon	1951-57	
		Montgomery					Model	1951-57	Indian Mound	1951-57	
		Stewart					(complete)		Johnson Hollow	1951-57	
									Linton	1957-67	
									New Providence	1951-57	
									Oak Grove	1951-57	
									Roaring Springs	1951-57	
									Woodlawn	1951-57	
									(complete)		
Ft. Carson	CO	El Paso	Pikes Peak	1966	Pueblo	1954-62	Mt. Big Chief	1948	Buttes (MF482)	1948-61	MF 482
									Cheyenne Mtn.	1948-61	
									Colorado Springs	1948-61	
									Elsmere	1948-61	
									Fountain	1948-61	
									Mt. Pittsburg	1948-61	
									Pierre Gulch	1963	
									Steele Hollow	1961	
									Stone City	1963	
									Timber Mtn.	1948-61	
									(complete)		
Ft. Chaffee	AR	Sebastian	Vicksburg	1956	Ft. Smith	1946	Barber	1947	Barber	1947	
		Franklin					Greenwood	1947	Barling	1947	
							Lavaca	1947	Burnville	1947	
							Van Buren	1947	Charleston	1947	
							(complete)		Greenwood	1948	
									Lavaca	1947	
									(complete)		
Ft. Devens	MA	Middlesex	Boston	1955	Boston	1956-70	(none)		Ayer	1923-66	
		Worchester							Shirley	1923-65	
									(complete)		

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
Ft. Dix	NJ	Ocean	Hudson River	1955	Newark	1944-69	Bardenton	1948	Browns Mill	1949-57	
		Burlington	Chesapeake Bay	1955	Wilmington	1966-72	Lakehurst	1948	Cassville	1948-57	
							Pemberton	1949	Columbus	1948-57	
							Whiting	1949	New Egypt	1948-57	
							(complete)		Pemberton	1949-57	
									Whiting	1949-57	
									(complete)		
Ft. Douglas	UT	Salt Lake	Great Salt Lake	1955	Salt Lake City	1954-70	(none)		Dugway Proving Ground NE	1954	
					Tooele	1953-70			Dugway Proving Ground NW	1954	
									Dugway Proving Ground SW	1954	
									Dugway Proving Ground SE	1954	
									Granite Peak SE	1954	
									Granite Peak	1954	
									Camels Back Ridge SW	1955	
									Camels Back Ridge NE	1954	
									Camels Back Ridge NW	1954	
									Davis Knolls	1955	
									Tabby's Peak SW	1955	
									Tabby's Peak SE	1955	
									Simpson Springs	1955	
									Wing Mtn.	1955	
									Wing Mtn. SW	1955	
									Wing Mtn. NE	1955	
									Wing Mtn. NW	1954	
									Wildcat Mtn. SE	1954	
									(complete)		
Ft. Drum	NY	Jefferson	Hudson River		Ogdensburg	1943	Antwerp	1949	Antwerp	1949	
			(complete)		Rochester	1961	(incomplete)		Black River	1958	
					Utica	1962			Defereit	1949	
									Lake Bonaparte	1951	
									Natural Bridge	1951	
									N. Wilna	1949	
									Philadelphia	1949	
									(complete)		
Ft. Eustis	VA	Newport News	Chesapeake Bay	1955	Richmond	1943-73	(none)		Mulberry Island	1965	
									Yorktown	1965	
									(complete)		
Fitzsimmons Army Medical Center	CO	Adams	Pikes Peak	1966	Denver	1953-63	(none)		Fitzsimmons	1965	
									Sable	1938-65	
									(complete)		
Ft. Gillem	GA	Clayton	Lookout Mtn.	1968	Atlanta	1953-70	(none)		Jonesboro	1954	
									Riverdale	1954	
									(complete)		

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
Ft. Gordon	GA	Richmond	Savannah	1946	Athens	1953-65	Harlem	1948	Augusta West	1947-57	
					Augusta	1957-69	Hephzibah	1948-57	Avondale	1947-57	
							(complete)		Blythe	1948	
									Grovetown	1947-57	
									Harlem	1948	
									(complete)		
Ft. Greely	AK	Fairbanks	Fairbanks	1956	Big Delta	1958	A4	1950	(none)		
		Ft. Yukon	Anchorage	1956	Mt. Hayes	1955	A5	1950			
					Healy	1956	A6	1949			
							B6	1949			
							C1	1950			
							C3	1950			
							C4	1950			
							C5	1950			
							C6	1953			
							D1	1949			
							D3	1950			
							D4	1949			
							D5	1950			
							D6	1952			
							(complete)				
Ft. Hamilton	NY	Kings	Hudson River	1955	Newark	1944-69	(none)		Coney Island	1955-66	
					New York	1957-69			The Narrows	1955-66	
									(complete)		
Ft. Benjamin Harrison	IN	Marion	Chicago	1973	Cincinnati	1953-74	(none)		Cumberland	1952-62	
			Louisville	1959	Indianapolis	1953-64			Fishers	1952-67	
									Indianapolis East	1946-67	
									McCordsville	1952-62	
									(complete)		
Ft. A. P. Hill	VA	Caroline	Chesapeake Bay	1955	Washington	1957-69	(none)		Bowling Green		
		Essex							Guinea		
									Port Royal		
									Rappahancock Academy		
									Supply		
									Woodford		
									(complete)		
Ft. Hood	TX	Coryell	Austin	1945	Waco	1954-75	Gatesville	1947-58	Bland	1947-58	
		Bell					Ft. Hood	1947-58	Copperas Cove	1947-58	
							Killeen	1947-58	Gatesville East	1947-57	
							Purmela	1947-58	Gatesville West	1947-57	
							(complete)		Ft. Hood	1947-58	
									North Ft. Hood	1947-58	
									Killen	1947-58	
									Leon Junction	1947-58	
									McMillan Mts.	1947-58	

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
									Nolanville	1947-58	
									Pidcoke	1947-58	
									Post Oak Mtn.	1947-58	
									Shell Mtn.	1947-58	
									Twin Mountains	1947-58	
									(complete)		
Ft. Sam Houston	TX	Bexar	Austin	1945	San Antonio	1954-64	(none)		San Antonio East	1953-67	
									(complete)		
Ft. Huachuca	AZ	Cochise	Gila River	1959	Nogales	1956-69	Ft. Huachuca	1948-58	Fairbank	1952	
			(incomplete)				Sunnyside	1948-58	Ft. Huachuca	1948-58	
							Tombstone	1952	Huachuca Peak	1948-58	
							(complete)		Huachuca Vista	1948-58	
									Lewis Springs	1952	
									Miller Peak	1948-58	
									Mustang Mtn.	1948-58	
									(complete)		
Hunter-Liggett	CA	Monterey	Los Angeles	1947	Santa Cruz	1965	Bradley	1948-61	Alder Peak	1949	
Military Reservation		San Luis Obispo			San Luis Obispo	1956-69	Bryson	1949-61	Bear Canyon	1949	
							Cape San Martin	1949-61	Bryson	1948	
							Junipero Serra	1947-61	Burnett Peak	1949	
							King City	1949-61	Burro Mtn.	1949	
							(complete)		Cape San Martin	1949	
									Cone Peak	1949	
									Cosio Knob	1948	
									Hames Valley	1949	
									Jolon	1948	
									Tierra Redonda Mtn.	1948	
									Williams Hill	1948	
									(complete)		
Ft. Jackson	SC	Richland	Savannah	1946	Augusta	1957-69	(none)		Congaree	1953-72	
					Spartanburg	1953-69			Ft. Jackson N.	1953-72	
									Ft. Jackson S.	1953-72	
									Leesburg	1953	
									Messers Pond	1953-72	
									(complete)		
Ft. Knox	KY	Bullitt	Louisville	1959	Evansville	1957-74	Ekron	1947	Colesburg	1945-60	
		Hardin			Louisville	1956-69	Vine Grove	1946	Flaherty	1947-60	
		Mead			Winchester	1957-67	(complete)		Ft. Knox	1946-60	
									Pitts Point	1946-60	
									Rock Haven	1946-60	
									Vinegrove	1946-60	
									(complete)		
Ft. Leavenworth	KS	Leavenworth	Ozark Plateau	1971	Kansas City	1956-66	Leavenworth	1948	Leavenworth	1948-61	
							(complete)		Weston	1948-61	
									(complete)		

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
Ft. Lee	VA	Prince George	Chesapeake Bay	1955	Richmond	1943-73	(none)		Hopewell	1940-69	
									Prince George	1952-69	
									(complete)		
Ft. Lewis	WA	Pierce	Cascade Range	1945	Seattle	1958-74	Anderson Island	1948-59	Harts Lake	1959	
					Hoquiam	1958-74	Ohop Valley	1959	Ft. Lewis	1948-59	
							Tacoma South	1959-61	McKenna	1959	
							Tenino	1959	McNeil Island	1948-59	
							Yelm	1959	Nisqually	1948-59	
							(complete)		East Olympia	1959	
									Spanaway	1959	
									Steilacoom	1948-59	
									Weir Prairie	1959	
									(complete)		
Ft. McArthur	CA	Los Angeles	Los Angeles	1947	Long Beach	1957-70	(none)		San Pedro	1964	
									Torrance	1964	
									Long Beach	1928-64	
									(complete)		
Ft. McClellan	AL	Calhoun	Lookout Mtn.	1968	Atlanta	1953-70	Anniston	1947	Anniston	1947-56	
					Birmingham	1953-69	Jacksonville	1947	Choccolocco	1954	
							Ragland	1947	Eulation	1947-56	
							(complete)		Francis Mill	1947	
									Ohatchee	1947	
									Wellington	1947-56	
									(complete)		
Ft. McCoy	WI	Monroe	Minneapolis	1955	Eau Claire	1953-64	Millstone	1947	(none)		
					LaCrosse	1958	Tomah	1947			
							(complete)				
Ft. McPherson	GA	Fulton	Lookout Mtn.	1968	Atlanta	1953-70	(none)		Southwest Atlanta	1954	
									(complete)		
Ft. Meade	MD	Anne-Arundel	Chesapeake Bay	1955	Baltimore	1957-69	Laurel	1943-65	Laurel	1943-65	
							(incomplete)		Odenton (complete)	1943-57	
Ft. Monroe	VA	Hampton City	Chesapeake Bay	1955	Richmond	1943-73	(none)		Hampton	1965	
									(complete)		
Ft. Ord	CA	Monterey	Los Angeles	1947	Santa Cruz	1965	Monterey	1947	Marina	1947	
							Salinas	1947	Spreckels	1947	
							(complete)		Salinas	1947	
									Seaside	1947	
									(complete)		
Ft. Pickett	VA	Brunswick	Chesapeake Bay	1955	Richmond	1943-73	(none)		Blackstone E	1966	
		Dinwiddie							Danieltown	1951	
		Lunenburg							Darvills	1964	
									Warfield	1951	
									(complete)		

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
Ft. Polk	LA	Sabine	MI Delta	1945	Alexandria	1953-73	Leander	1954	Birds Creek	1954	
		Vernon	White Lake	1955	Lake Charles	1954-72	Slagle	1954	Burton Creek	1954	
		Natchitoches					(complete)		Fullerton Lake	1954	
									La Camp	1954	
									Leander SE	1954	
									Ft. Polk	1954	
									Slagle	1954	
									(complete)		
Ft. Richardson	AK	Anchorage	Anchorage	1965	Anchorage		A7	1960	(none)		
					& vicinity	1962	A8	1952			
					(complete)		B7	1960			
							B8	1952			
							(complete)				
Ft. Riley	KA	Geary	Wichita	1955	Manhattan	1955-69	Ft. Riley	1947	Ft. Riley NE	1947-55	
		Riley					(incomplete)		Keats	1947-55	
									Junction City	1947-55	
									Milford	1947-55	
									Alida	1947-55	
									Ogden	1947-55	
									Riley	1964	
									Bala	1963	
									(complete)		
Ft. Rucker	AL	Coffee	Mobile	1959	Dothan	1953-65	Brundidge	1948	Brundidge SE	1948-60	
		Dale					Enterprise	1948	Daleville	1948-60	
							Ozark	1948	Enterprise	1948-60	
							(complete)		Enterprise NE	1948-60	
									Ozark	1948-60	
									Pinckard	1948-60	
									(complete)		
Presido of San Francisco	CA	San Francisco	San Francisco		San Francisco	1956-69	(none)		(none)		
			Bay	1959							
Fort Shafter	HI	Oahu	Hawaii	1971	Oahu	1970	Honolulu		Honolulu	1927-69	
					Maui	1961	& vicinity	1927-54	(complete)		
							(complete)				
Ft. Sheridan	IL	Lake	Chicago	1973	Racine	1958-69	(none)		Ft. Highland	1926-63	
									(complete)		
Ft. Sill	OK	Comanche	Dallas	1959	Lawton	1955-74	Apache	1949-56	Arbuckle Hill	1949-56	
							Cache	1949-56	Cooperton	1949-56	
							Copperton	1949-56	Elgin	1949-56	
							Lawton	1949-56	Meers	1949-56	
							Saddle Mtn.	1949-56	Odetta	1950-56	
							Snyder	1950-56	Quanah Mtn.	1949-56	
							(complete)		Saddle Mtn.	1949-56	
									Mt. Scott	1949-56	
									Ft. Sill	1949-56	
									(complete)		

Installation	State	County	U.S.G.S. Maps 1:1,000,000		1:250,000		1:62,500 1:62,500 or 15′		1:24,000 or 7.5′		Geologic or Misc. Map
Ft. Stewart	GA	Bryan	Savannah	1948	Brunswick	1956-68	Claxton	1948	Glenville	1948-58	
		Evans	Jacksonville	1956	Savannah	1957-67	Glennville	1948	Glenville NE	1948-58	
		Liberty					Limerick	1948	Glissons Millpond	1948-58	
		Long					Pembroke	1948	Hinesville	1948-58	
		Tattnal					(complete)		Letford	1948-58	
									Limerick NW	1948-58	
									Meldrim SE	1948-58	
									Meldrim SW	1948-58	
									Richmond Hill	1948-58	
									Taylors Creek	1948-58	
									Trinity	1948-58	
									Walthourville	1948-58	
									Willie	1948-58	
									(complete)		
Ft. Wainwright	AK	4th Judicial	Fairbanks	1956	Big Delta	1958	B1	1950	(none)		
		Division			Fairbanks	1953	B2	1950			
					(complete)		B3	1949			
							B6	1949			
							C1	1950			
							C2	1949			
							C3	1950			
							C4	1950			
							D1	1949			
							D2	1949-52			
							(complete)				
Ft. Leonard Wood	MO	Polaski	Ozark Plateau	1971	Springfield	1954-69	Drynob	1954	Bloodland	1954	
							Big Piney	1954	Brownfield	1954	
							Waynesville	1954	Devils Elbow	1954	
							(complete)		Big Piney	1954	
									Roby	1954	
									Waynesville	1954	
									Winnipeg	1954	
									(complete)		
Yakima Firing Center	WA	Kittitas	Cascade Range	1945	Walla Walla	1953-63	Badger Pocket		Badger Gap	1953	
		Yakima	Snake River	1960	Yakima	1953-71	Beverly		Beverly	1954-65	
							Black Rock Spring		Black Rock Springs	1953	
							Boylston		Black Rock Springs SW	1953	
							Priest Rapids		Black Rock Springs NE	1953	
							Yakima East		Black Rock Springs NW	1953	
							(complete)		Cairn Hope Peak	1950	
									Doris	1953	
									Elephant Mtn.	1953	
									McDonald Spring	1953	
									Pomona	1953	
									Priest Rapids	1950	
									Selah Springs	1953	
									(complete)		

APPENDIX B: STATUS OF SCS SOIL SURVEYS AVAILABLE FOR MAJOR U.S. ARMY MILITARY INSTALLATIONS

This appendix was compiled from the list of published soil surveys issued by the SCS in January 1977. Since soil surveys require several years to produce and since many surveys are now being conducted, an attempt was made to include information about relevant surveys in progress. This information was obtained by contacting state conservationists. For the most part, sub-installations and separate parcels of land located in a county different from that of the main installation were not included. The selected list of installations is the same as the list in Appendix A. This appendix is organized alphabetically by state.

State	Installation	Counties	Published Surveys (Pre 1950*)	Published Surveys (1950-Present)	Survey in Progress and Other Remarks
AL					
	Ft. Benning	Russell	1913*	---	
	Ft. McClellan	Calhoun	1908*	1961	
	Ft. Rucker	Dale	1910*	1960	
		Coffee	1909*	---	DCA
AK					
	Ft. Greely	Fairbanks	---	1963	
		Ft. Yukon	---	---	
	Ft. Richardson	Anchorage	---	---	DCA
	Ft. Wainwright	Fairbanks	---	1963	
AZ					
	Ft. Huachuca	Cochise	---	---	CBM
	Ft. Huachuca	Markopa	---	1974	DCA
	–Gila Bend Area	Yuma	1902*	---	
			1942	---	
	–Willcox Area	Graham	1956	1976	
		Navajo	1956	1976	
AR					
	Ft. Chaffee	Sebastian	---	1975	
		Franklin	---	1971	
CA					
	Hunter-Liggett	Monterey	---	1978	
	Ft. MacArthur	Los Angeles	1903*	---	CBM
			1916*		
	Ft. Ord	Monterey	---	1978	
	San Francisco, Presido of	San Francisco	1914*	---	
CO					
	Ft. Carson	El Paso	---	---	DCA
	Fitzsimmons Army Medical Center	Adams	---	1974	
GA					
	Ft. Benning	Chattahoochie	1924*	---	CBM
		Muscogee	1922*	---	CBM
	–Tng Area	Lumpkin	---	1972	Dawson, Lumpkin, and White
	Ft. Gillem	Clayton	---	---	DCA–Clayton, Fayette, and Henry

*OP indicates survey is out of print
DCA–indicates draft copy available
CBM–indicates currently being mapped

State	Installation	Counties	Published Surveys (Pre 1950*)	(1950-Present)	Survey in Progress and Other Remarks
	Ft. Gordon	Columbia	1911*	---	DCA–Columbia, McDuffie, and Warren
		Jefferson	1930*	---	CBM
		McDuffie	1937*	---	DCA–Columbia, McDuffie, and Warren
	–Oliver Area	Richmond	1916*	---	DCA
	–Rear Area				
	Ft. McPherson	Fulton	---	1958	
	Ft. Stewart	Liberty and Long	---	---	CBM
		Bryan	---	1974	
		Candler, Evans	---	---	CBM
		Tattnal	1914*	---	DCA
HI					
	Ft. Shafter	Honolulu	---	1972	
IL					
	Ft. Sheridan	Lake	---	1970	
IN					
	Ft. Benjamin Harrison	Marion	1907*	---	DCA for Marion County and Ft. Benjamin Harrison
KS					
	Ft. Leavenworth	Leavenworth	1919*	1977	Leavenworth and Wiandott
	Ft. Riley	Geary	---	1960	
		Riley	---	1975	
KY					
	Ft. Campbell	Christian	1912*	---	CBM
		Trigg	---	---	CBM
	Ft. Knox	Hardin	---	---	CBM
		Meade	---	---	CBM
		Bullitt	---	---	DCA
LA					
	Ft. Polk	Vernon	---	---	Individual Scattered Tracks Only
		Sabine	1919*	---	Individual Scattered Tracks Only
		Natchitoches	1921*	---	CBM
MD					
	Aberdeen Proving Ground	Harford	1901* & 1927*	1975	
		Baltimore	1917*	1976	
	Ft. George Meade	Anne Arundel	1909* & 1929*	1973	
MA					
	Ft. Devens	Middlesex	1924*	---	CBM
		Worchester	1922*	---	CBM in Three Separate Sections
MO					
	Ft. Leonard Wood	Laclede	1911*	---	CBM
		Phelps	---	---	CBM
		Pulaski	---	---	CBM
NJ					
	Ft. Dix	Burlington	---	1971	
		Ocean	---	---	DCA in Two Separate Sections
NY					
	Ft. Drum	Jefferson	1911*	---	CBM
		Lewis	---	1960	
		St. Lawrence	1925	---	CBM

State	Installation	Counties	Published Surveys (Pre 1950*)	(1950-Present)	Survey in Progress and Other Remarks
NC					
	Ft. Bragg	Cumberland	1922*	---	CBM–DCA in 1½ Yrs
		Hoke	1918*	---	CBM–DCA in 1½ Yrs
OK					
	Ft. Sill	Comanche	---	1967	
SC					
	Ft. Jackson	Richland	1916*	---	DCA
TN					
	Ft. Campbell	Montgomery	1901*	1975	
		Stewart	---	1953	
TX					
	Ft. Bliss	El Paso	---	1971	
	Ft. Hood	Bell	1916*	1977	
		Coryell	---	---	Preparations for Mapping Are Being Made
	Ft. Sam Houston	Bexar	---	1966	
UT					
	Ft. Douglas	Salt Lake	1946	1974	
VA					
	Ft. Belvoir	Fairfax	1915*	1965	
	Ft. Eustis	Newport News	---	---	
	Ft. A.P. Hill	Caroline	---	---	
		Essex	---	---	
	Ft. Lee	Prince George	---	---	CBM
	Ft. Monroe	Hampton City	---	---	
	Ft. Pickett	Brunswick	---	---	
		Dinwiddie	---	---	
		Lunenburg	---	---	DCA
WA					
	Ft. Lewis	Pierce	---	1955	
		Thurston	---	1958	
	Yakima Firing Center	Yakima	1901*	1958	
		Kittitas	1945	---	
WI					
	Ft. McCoy	Monroe	1923*	---	CBM

APPENDIX C:
STATUS OF USGS GEOLOGIC AND HYDROLOGIC MAPS AVAILABLE FOR MAJOR U.S. ARMY MILITARY INSTALLATIONS

This appendix is compiled from the most recent available state lists of "Geologic and Water-Supply Reports and Maps." The lists for Massachusetts (Devens) and South Carolina (Jackson) were unavailable. In addition, Figure 53 of the USGS 1976 Annual Report was consulted for updated information on hydrologic unit maps. This appendix is organized similarly to Appendix B. While these state lists include information on both reports and maps, only maps from the installations considered in Appendices A and B are referenced here. These "Geological Water-Supply Reports and Maps" reference only USGS publications. Appendix F provides more recently compiled information on geologic maps produced by USGS and other agencies for states in which compilations have been completed.

State	Installation	Description	Date	Scale	Region or Quad	Author	Reference Number
AL	Ft. Benning, McClellan,						
	Rucker	Geologic Map Index	1971	1:1,000,000			
		Hydrologic Unit Map	1975	1:500,000			
AK	Ft. Greely, Richardson,						
	Wainwright	Geologic Map	1957	1:2,500,000		Dutro & Payne	
		Geologic Map Index	1967	1:2,500,000			
		Geologic Quadrangle Maps					
	Ft. Wainwright		1958	1:63,360	Fairbanks (D-2)	Péwé	GQ-110
	Ft. Wainwright		1959	1:63,360	Fairbanks (D-1)	Williams, Péwé, & Paige	GQ-124
	Ft. Greely		1970	1:63,360	Fairbanks (A-4)	Wahrfatig	GQ-810
	Ft. Greely		1970	1:63,360	Fairbanks (A-5)	Wahrfatig	GQ-811
		Miscellaneous Field Studies Maps					
	Ft. Greely and Wainwright	Metallic mineral resource map			Big Delta	Cobb	MF-388
	Greely and Wainwright	Metallic mineral resource map			Healy	Cobb & Clark	MF-394
	Greely and Wainwright	Metallic mineral resource map			Mt. Hayes	Cobb	MF-414
	Wainwright	Metallic mineral resource map			Fairbanks	Cobb	MF-410
	Richardson	Metallic mineral resource map			Anchorage	Cobb	MF-409
		Miscellaneous Investigations Series					
	Wainwright		1966	1:250,000	Fairbanks	Pewe & Weber	I-455
		Hydrologic Unit Map	1976	1:500,000			
AZ	Ft. Huachuca						
		Geologic Map Index	1963	1:1,000,000		Boardman & Young	
		Geologic Map	1969	1:500,000		Wilson & Moore	
		Hydrologic Investigations Atlases					
		Flouride content & salinity of groundwater	1966	NA	Willcox Basin	Kister & Brown	HA-214
		Hydrologic Unit Map	1976	1:500,000			
		Miscellaneous Field Studies Maps					
		Reconnaissance geologic map	1959	1:125,000	Cochise County	Cooper	MF-213
		Reconnaissance geologic map	1960	1:62,500	Cochise & Graham Counties	Cooper	MF-231
		Miscellaneous Investigations Series					
		Geologic Map	1968	1:48,000	Huachuca & Mustang Mtns.	Hayes & Raup	
AR	Ft. Chaffee						
		Geologic Map Index	1952	1:500,000		Boardman & Young	
		Hydrologic Unit Map	1976	1:500,000			

State	Installation	Description	Date	Scale	Region or Quad	Author	Reference Number
CA	Presidio of San Francisco and Ft. Ord						
		Geologic Map Index	1952	1:750,000			
		Hydrologic Unit Map	1976	1:500,000			
		Miscellaneous Field Studies Maps					
	Presidio of San Francisco	Active faults & preliminary earthquake epicenters	1970	1:250,000	S. San Francisco Bay	Brown & Lee	MF-307
	Presidio of San Francisco	Locations of samples dated by radiocarbon methods	1971	1:500,000	San Francisco Bay region	Wright	MF-317
	Presidio of San Francisco	Distribution of structurally damaging landslides	1969	1:500,000	San Francisco Bay region	Peterson, Taylor, Brabb	MF-327
	Presidio of San Francisco	Fault map	1972	1:250,000	San Francisco Bay region	Brown	
	Presidio of San Francisco	Isopleth map of landslide deposits	1974	1:125,000	S. San Francisco Bay region	Wright & Nilsen	MF-550
	Presidio of San Francisco	Predicted maximum earthquake intensity	1975	1:125,000	S. San Francisco Bay region	Borcherdt, Gibbs	MF-509
	Ft. Ord	Faults & earthquakes	1973	1:200,000	Monterey Bay region	Greene, Lee, McCulloch	MF-518
	Ft. Ord	Preliminary geologic map	1974	1:24,000	Monterey & Seaside	Clark, Diblee, Greene, & Braun	MF-577
CO	Fitzsimmons Army Medical Center and Ft. Carson						
		Hydrologic Unit Map	1976	1:500,000			
		Geologic Map	1935	1:500,000		Burbank, Lovering, Goddard	
		Geologic Map Index	1954	1:750,000		Boardman	
		Geologic Map Index, Part B	1972	1:1,000,000		McIntosh & Gister	
GA	Ft. Gordon						
		Hydrologic Unit Map	1976	1:500,000			
		Geologic Map Index	1949	1:750,000		Boardman, Braun, & Watson	
		Camp Gordon and Vicinity	1918	1:125,000			
HI	Ft. Shafter						
		Hydrologic Unit Map	1976	1:500,000			
IL	Ft. Sheridan						
		Geologic Map Index	1954	1:750,000		Boardman & Young	
		Hydrologic Unit Map	1976	1:500,000			
IN	Ft. Benjamin Harrison						
		Geologic Map Index	1950	1:750,000		Boardman, Braun, & Watson	
		Hydrologic Unit Map	1975	1:500,000			

State	Installation	Description	Date	Scale	Region or Quad	Author	Reference Number
KS	Ft. Leavenworth and Riley						
		Geologic Map Index	1954	1:750,000		Boardman & Young	
		Hydrologic Unit Map	1976	1:500,000			
KY	Ft. Campbell and Knox						
		Geologic Map Index	1952	1:750,000		Boardman	
		Geologic Quadrangle Maps					
	Knox		1963	NA	Flaher[illegible]	Swadley	GQ-329
	Knox		1966	NA	Oak Grove	Klemic	GQ-665
	Knox		1967	NA	[illegible]	Kepferle	GQ-602
	Knox		1967	NA	Vine Grove	Klemic	GQ-645
	Campbell		1966	NA	Herndon	Klemic	GQ-572
	Campbell		1968	NA	Johnson Hollow	Klemic	GQ-722
		Hydrologic Investigations Atlases					
	Campbell		1963	NA	Caldwell, Christian, Crittenden, Livingston, Lyon, Todd, and Trigg Counties		HA-34
	Campbell		--	NA	Bath, Fleming, & Montgomery Counties		HA-18
	Knox		--	NA	Bullitt, Jefferson & Oldham Counties		HA-22
LA	Ft. Polk						
		Geologic Map Index	1950	1:1,000,000		Boardman	
MD	Aberdeen Proving Ground and Ft. Divens						
		Geologic Map Index	1972	1:500,000		McIntosh & Gister	
		Hydrologic Unit Map	1975	1:500,000	MD, DEL. & D.C.		
MA	Ft. Devens						
		Geologic Map Index	1952	1:500,000		Boardman	
		Hydrologic Unit Map	1975	1:500,000			
MO	Ft. Leonard Wood						
		Geologic Map Index	1949	1:750,000		Boardman & Braun	
		Base State Map	1973	1:1,000,000			
		Topographic State Map	1973	1:500,000			
NJ	Ft. Dix						
		Geologic Map Index	1951	1:500,000			
		Hydrologic Unit Map	1975	1:500,000			
		Geologic Quadrangle Maps					
		Pre-Quaternary geology	1962	1:24,000	Columbus	Minard and Owens	GQ-160
		Pre-Quaternary geology	1962	1:24,000	New Egypt	Minard and Owens	GQ-161
		Pre-Quaternary geology	1964	1:24,000	Pemberton	Minard and Owens	GQ-162
		Pre-Quaternary geology	1963	1:24,000	Browns Mills	Minard and Owens	GQ-164

State	Installation	Description	Date	Scale	Region or Quad	Author	Reference Number
NY	Ft. Drum						
		Geologic Map Index	1952	1:750,000		Boardman	
		Base State Map	1974	1:500,000			
		Topographic State Map	1974	1:500,000			
		Hydrologic Unit Map	1975	1:500,000			
NC	Ft. Bragg						
		Geologic Map Index	1950	1:750,000		Boardman and Watson	
		Hydrologic Unit Map	1976	1:500,000			
		Base State Map	1972	1:1,000,000			
		Topographic State Map	1972	1:500,000			
OK	Ft. Sill						
		Geologic Map Index	1953	1:750,000		Boardman	
		Geologic Map	1954	1:500,000		Miser	
		Hydrologic Unit Map	1975	1:500,000			
SC	*Ft. Jackson*						
		Geologic Map Index	1950	1:1,000,000		Boardman	
		Hydrologic Unit Map	1976	1:500,000			
TN	Ft. Campbell						
		Geologic Map Index	1972	1:750,000			
		Geologic Quadrangle Maps					
			1966	1:24,000	Oak Grove	Klemic	GQ-565
			1966	1:24,000	Herndon	Klemic	GQ-672
			1967	1:24,000	Roaring Spring	Klemic	GQ-653
		Base State Map	1973	1:1,000,000			
		Base State Map	1973	1:500,000			
		Topographic State Map	1973	1:500,000			
TX	Ft. Bliss, Hood, Houston						
		Geologic Map	1937	1:500,000		Stose	
		Geologic Map Index	1951	1:1,000,000		Boardman	
		Hydrologic Unit Map	1976	1:500,000			
UT	Ft. Douglas						
		Geologic Map Index	1954	1:750,000		Boardman	
		Hydrologic Unit Map	1976	1:500,000			
		Geologic Quadrangle Map	1972	1:24,000	Dugway Proving Ground SW	Staatz	GQ-992

State	Installation	Description	Date	Scale	Region or Quad	Author	Reference Number
VA	Ft. Belvoir, Eustis, Hill, Lee, Monroe, Pickett	Geologic Map Index	1959	1:500,000		Boardman	
		Hydrologic Unit Map	1975	1:500,000			
WI	Ft. McCoy	Geologic Map Index	1971	1:1,000,000			
		Hydrologic Unit Map	1976	1:500,000			
WA	Yakima Firing Center and Ft. Lewis	Geologic Map Index	1949	1:750,000		Boardman	
		Hydrologic Unit Map	1976	1:500,000			
		Geophysical Investigations Maps					
	Ft Lewis		1958	1:62,500	Tenino	Henderson	GP-181
	Lewis		1958	1:62,500	Yelm	Henderson	GP-182

APPENDIX D: STATUS OF GEOLOGIC QUADRANGLE MAPS AT 1:250,000 SCALE AVAILABLE FOR MAJOR U.S. ARMY MILITARY INSTALLATIONS

This appendix is compiled from an index status map, *Small-Scale Published Geologic Maps– Primary Sources (1:200,000, 1:250,000)*, compiled by USGS in January 1978 and hand-updated by the USGS Geologic Inquiry Group Staff in July 1978. This index and other information on geologic maps is available from the Geologic Inquiry Group, USGS, 907 National Center, Reston, VA 22092, telephone (703) 860-5617, or FTS 928-6517.

Only those installations and 1:250,000 scale quadrangles listed in Appendix A are considered for this appendix, which is organized alphabetically by installations. USGS is now placing major emphasis on its 1:250,000 geologic mapping program, especially open-file reports, so many more of these reports (maps) are likely to become available soon.

Installation	State	1:250,000 Quadrangle	Publishing Agency	Type Maps	Reference Number
Aberdeen Proving Ground	MD	Baltimore	SM	C	
Ft. Belvoir	VA	Washington	SM	C	
Ft. Benning	GA	Phenix City	--		
Ft. Bliss	TX, NM	Carlsbad	--		
		El Paso	SM	C	
		Vanttarn	SM	C	
Ft. Bragg	NC	Florence	--		
		Raleigh	--		
Ft. Campbell	KY, TN	Nashville	SM	CB	
Ft. Carson	CO	Pueblo	USGS	B&W	MF-775 '76
Ft. Chaffee	AR	Ft. Smith	--		
Ft. Devens	MA	Boston	USGS	B&W	OF-77-285
Ft. Dix	NJ	Newark	SM	C	
		Wilmington	SM	C	
Ft. Douglas	UT	Salt Lake City	SM	CB	
		Tooele	SM+	CB	
			USGS	B&W	OF-78-257
Ft. Drum	NY	Ogdensburg	SM	CB	
		Utica	SM	CB	
Ft. Eustis	VA	Richmond	--		
Fitzsimmons	CO	Denver	USGS	BW	OF-78-397
Ft. Gillem	GA	Atlanta			
Ft. Gordon	GA	Athens	--		
		Augusta	--		

Symbols Key

Publishing Agency:

SM = State Agency
USGS = United States Geological Survey

Type of Map:

CB – Publishing in color or topographic base
C – Published in color, not as topo base
B&W – Published in black and white

Installation	State	1:250,000 Quadrangle	Publishing Agency	Type Maps	Reference Number
Ft. Greely	AK	Big Delta	N/A		
		Mt. Hayes	N/A		
		Healy	N/A		
Ft. Hamilton	NY	Newark	SM	C+	
			USGS	B&W	OF-78-595
		New York	SM	CB	
Ft. Ben Harrison	IN	Cincinnati	SM	C	
		Indianapolis	SM	C	
Ft. A. P. Hill	VA	Washington	SM	C	
Ft. Hood	TX	Waco	SM	CB	
Ft. Sam Houston	TX	San Antonio			
Ft. Huachuca	AZ	Nogales	--		
Hunter-Liggett	CA	Santa Cruz	SM	CB	
		San Luis Obispo	SM	CB	
Ft. Jackson	SC	Augusta	--		
		Spartanburg	--		
Ft. Knox	KY	Louisville	SM	C	
		Winchester	--		
		Evansville	--		
Ft. Leavenworth	KS	Kansas City	--		
Ft. Lee	VA	Richmond	--		
Ft. Lewis	WA	Seattle	--		
		Hoquiam	--		
Ft. MacArthur	CA	Long Beach	SM	CB	
Ft. McClellan	AL	Atlanta	--		
		Birmingham	--		
Ft. McCoy	WI	Eau Claire	--		
		La Crosse	--		
Ft. McPherson	GA	Atlanta	--		
Ft. Meade	MD	Washington	SM	C	
Ft. Monroe	VA	Richmond	--		
Ft. Ord	CA	Santa Cruz	SM	CB	
Ft. Pickett	VA	Richmond	--		
Ft. Polk	LA	Alexandria	Partial SM	CB	
Ft. Richardson	AL	N			
Ft. Riley	KS	Manhattan	None		
Ft. Rucker	AL	Dothan	None		

Installation	State	1:250,000 Quadrangle	Publishing Agency	Type Maps	Reference Number
Presidio of San Francisco	CA	San Francisco	SM	CB	
Ft. Shafter	HI	Oahu	N/A		
		Maui	N/A		
Ft. Sheridan	IL	Racine	None		
Ft. Sill	OK	Lawton	None		
Ft. Stewart	GA	Savannah	None		
		Brunswick	None		
Ft. Wainwright	AK	Big Delta	N/A		
		Fairbanks	N/A		
Ft. Leonard Wood	MO	Springfield	None		
Yakima Firing Center	WA	Walla Walla	None		
		Yakima	None		

APPENDIX E:
LISTING OF THE MEMBERS OF THE ASSOCIATION OF AMERICAN STATE GEOLOGISTS

1977 DIRECTORY
ASSOCIATION OF AMERICAN STATE GEOLOGISTS

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1978

ALABAMA (205) 349-2852
Thomas J. Joiner
Geol. Survey of Alabama
P.O. Drawer O
University, AL 35486

ALASKA (907) 279-1433
Ross G. Schaff *(Dr.)*
Div. of Geology and
Geophysical Surveys
3001 Porcupine Drive
Anchorage, AK 99501

ARIZONA (602) 884-1401
William H. Dresher *(Dr.)*
Arizona Bureau of Geology
and Mineral Technology
Univ. of Arizona
Tucson, AZ 84721

ARKANSAS (501) 371-1488
Norman F. Williams
Arkansas Geol. Commission
Vardelle Parham Geol. Center
3815 W. Roosevelt Road
Little Rock, AR 72204

CALIFORNIA (916) 445-1923
Tom E. Gay, Jr.
Div. of Mines & Geology
Calif. Dept. of Conservation
1416 9th St., Room 715
Sacramento, CA 95814

COLORADO (303) 892-2611
John W. Rold
Colorado Geological Survey
1313 Sherman St., Room 715
Denver, CO 80203

CONNECTICUT (203) 566-3540
Hugo F. Thomas *(Dr.)*
Conn. Geol. & Natural History
Survey
State Office Bldg., Room 553
165 Capitol Ave.
Hartford, CT 06115

DELAWARE (302) 738-2833
Robert R. Jordan *(Dr.)*
Delaware Geological Survey
University of Delaware
Newark, DE 19711

FLORIDA (904) 488-4191
Charles W. Hendry, Jr.
Bureau of Geology
903 W. Tennessee St.
Tallahassee, FL 32304

GEORGIA (404) 656-3214
Sam M. Pickering, Jr.
Geol. & Water Resources Div.
Dept. of Natural Resources
19 Hunter St., SW
Atlanta, GA 30334

HAWAII (808) 548-7333
Robert T. Chuck
Div. of Water & Land Develop.
Dept. of Land & Natural Res.
P.O. Box 373
Honolulu, HI 96809

IDAHO (208) 885-6785
Maynard H. Miller
Idaho Bur. of Mines & Geol.
Moscow, ID 83843

ILLINOIS (217) 344-1481
Jack A. Simon
Illinois State Geol. Survey
121 Natural Resources Bldg.
Urbana, IL 61801

INDIANA (812) 337-2862
John B. Patton *(Dr.)*
Dept. of Natural Resources
Indiana Geological Survey
611 North Walnut Grove
Bloomington, IN 47401

IOWA (319) 338-1173
Stanley C. Grant *(Dr.)*
Iowa Geological Survey
Geol. Survey Bldg.
123 N. Capitol
Iowa City, IA 52242

KANSAS (913) 864-3965
William W. Hambleton *(Dr.)*
State Geol. Survey of Kansas
Raymond C. Moore Hall
1930 Ave. A, Campus West
Lawrence, KS 66044

KENTUCKY (606) 258-8991
Wallace W. Hagan *(Dr.)*
Kentucky Geological Survey
University of Kentucky
307 Mineral Indust. Bldg.
Lexington, KY 40506

LOUISIANA (504) 389-5812
Harry L. Roland, Jr.
Louisiana Geol. Survey
Box G, Univ. Station
Baton Rouge, LA 70803

MAINE (207) 289-2801
Robert G. Doyle
Maine Geological Survey
State Office Bldg., Room 211
Augusta, ME 04330

MARYLAND (301) 235-0771
Kenneth N. Weaver, *Director*
Maryland Geological Survey
Merryman Hall
Johns Hopkins University
Baltimore, MD 21218

MASSACHUSETTS (617) 727-4793
Joseph A. Sinott
Dept. of Environmental
Quality Engineering
Div. of Waterways–Room 532
100 Nashua St.
Boston, MA 02114

MICHIGAN (517) 373-1256
Arthur E. Slaughter
Michigan Dept. of Natural Resources
Geological Survey Division
P.O. Box 30028
Lansing, MI 48909

MINNESOTA (612) 373-3372
Matt Walton *(Dr.)*
Minnesota Geological Survey
1633 Eustis Street
St. Paul, MN 55108

MISSISSIPPI (601) 354-6228
William H. Moore
Miss. Geol., Econ., &
Topo. Survey
P.O. Box 4915
Jackson, MS 39216

MISSOURI (314) 364-1752
Wallace B. Howe *(Dr.)*
Div. of Geol. & Land Survey
P.O. Box 250
Rolla, MO 65401

MONTANA (406) 792-8321
Sid Groff *(Dr. Sidney L.)*
Mont. Bur. of Mines & Geol.
Montana College of Mineral
Science and Technology
Butte, MT 59701

NEBRASKA (402) 472-3471
Vincent H. Dreeszen
Conservation & Survey Div.
University of Nebraska
Lincoln, NE 68508

NEVADA (702) 784-6691
John Schilling
Nevada Bur. of Mines &
Geology
University of Nevada
Reno, NV 89507

NEW HAMPSHIRE (603) 862-1216
Glenn W. Stewart *(Prof.)*
Office of State Geologist
James Hall
Univ. of New Hampshire
Durham, NY 03824

NEW JERSEY (609) 292-2576
Kemble Widmer *(Dr.)*
New Jersey Bureau of
Geology & Topography
P.O. Box 2809
Trenton, NJ 08625

NEW MEXICO (505) 835-5420
Frank E. Kottlowski *(Dr.)*
New Mexico Bur. of Mines
& Mineral Resources
New Mexico Tech
Socorro, NM 87801

NEW YORK (518) 474-5816
James F. Davis *(Dr.)*
New York State Geol. Survey
State Education Building
Albany, NY 12224

NORTH CAROLINA (919) 829-3833
Stephen G. Conrad
Dept. of Nat. & Econ. Res.
P.O. Box 27687
Raleigh, NC 27611

NORTH DAKOTA (701) 777-2231
Lee C. Gerhard (Acting)
North Dakota Geol. Survey
University Station
Grand Forks, ND 58201

OHIO (614) 469-5344
Horace R. Collins
Ohio Div. of Geol. Survey
Fountain Square, Bldg. 6
Columbus, OH 43224

OKLAHOMA (405) 325-3031
Charles J. Mankin *(Dr.)*
Oklahoma Geological Survey
830 Van Vleet Oval, Rm. 163
Norman, OK 73069

OREGON (503) 229-5580
Donald A. Hull
State Dept. of Geology &
Mineral Industries
1069 State Office Bldg.
1400 SW Fifth Avenue
Portland, OR 97201

PENNSYLVANIA (717) 787-2169
Arthur A. Socolow *(Dr.)*
Bur. of Topo. & Geol. Survey
Dept. of Envir. Resources
P.O. Box 2357
Harrisburg, PA 17120

PUERTO RICO (809) 722-3142
Director
Servicio Geologico de P.R.
Dept. de Recursos Naturales
Apartado 5887, Puerta de
Tierra
San Juan, PR 00906

RHODE ISLAND
Robert L. McMaster
Assoc. State Geologist for
Marine Affairs
Grad. School of Oceanography
Kingston, RI 02881

SOUTH CAROLINA (803) 758-6431
Norman K. Olson
Div. of Geology
S.C. State Development Board
Harbison Forest Road
Columbia, SC 29210

SOUTH DAKOTA (605) 624-4471
Duncan J. McGregor *(Dr.)*
S. Dak. State Geol. Survey
Science Center
Univ. of South Dakota
Vermillion, SD 57069

TENNESSEE (615) 741-2726
Robert E. Hershey
Dept. of Conservation
Division of Geology
G-5 State Office Bldg.
Nashville, TN 37219

TEXAS (512) 471-1534
W. L. Fisher *(Dr.)*
Bur. of Economic Geology
University Station, Box X
Austin, TX 78712

UTAH (801) 581-6831
Donald T. McMillan
Utah Geol. & Mineral Survey
606 Black Hawk Way
Salt Lake City, UT 84108

VERMONT (802) 828-3357
Charles A. Ratte
Agency of Environmental
Conservation
5 Court Street
Montpelier, VT 05602

VIRGINIA (804) 293-5121
James L. Calver *(Dr.)*
Virginia Div. of Mineral Res.
P.O. Box 3667
Charlottesville, VA 22903

WASHINGTON (206) 753-6183
Vaughn E. Livingston, Jr.
Dept. of Natural Resources
Geol. & Earth Resources Div.
Olympia, WA 98504

WEST VIRGINIA (304) 292-6331
Robert B. Erwin *(Dr.)*
W. Va. Geol. & Econ. Survey
P.O. Box 879
Morgantown, WV 26505

WISCONSIN (608) 262-1705
Meredith E. Ostrom *(Dr.)*
Wisc. Geol. & Natural
History Survey
1815 University Ave.
Madison, WI 53706

WYOMING (307) 742-2054
Daniel N. Miller, Jr. *(Dr.)*
Wyoming Geological Survey
Box 3008, Univ. Station
Laramie, WY 82071

APPENDIX F: STATUS OF GEOLOGIC MAPS AVAILABLE FOR U.S. ARMY MILITARY INSTALLATIONS

This appendix was compiled from the recently issued USGS State Geologic Map Indexes. Since several of these state indexes are not yet published, N/A refers to installations located in these states. This appendix differs from Appendix C because it includes both maps published by USGS and by non-USGS sources. In addition, these lists were compiled from 1975 to the present and are therefore more current than the state list used to compile Appendix C. Maps listed in these states indexes which were listed in Appendix C have been omitted. This appendix is organized alphabetically by state, and only installations listed in Appendix A are considered.

State	Installation	Description	Scale	Author	Publisher
AL	Benning, McClellan, Rucker	N/A			
AK		None			
AZ	Ft. Huachuca				
	350	Hydrolic conditions in San Pedro	1:125,000	Roeske	Arizona Water Comm.
	358	River Valley. General geology of	1:62,500	Gilluly	U.S.G.S.
	79	Central Cochise County. Emplace-	1:220,000	Gilluly	Am. Jour. Sci.
	82	ment of Uncle Sam porphyry,	1:6,000	Butler	Arizona Bur. Mines Bull.
	371	Tombstone. Geology & ore	1:125,000	Olmstead	U.S.G.S.
	147	deposits of Tombstone district.	1:85,000	Brown	U.S.G.S.
	359	Geohydrology of Yuma area.	1:260,000	Darton	Arizona Bur. Mines Bull.
	290	Basic data concerning resume of Arizona geology. Geologic map of Huachuca & Mustang Mtns.	1:48,000	Hayes	U.S.G.S.
AR	Ft. Chaffee				
	106	Geology of Greenwood Quadrangle	1:48,000	Haley	U.S.G.S.
	108	Geology of Barber Quadrangle	1:48,000	Haley	Geol. Comm. Inf. Circ.
CO	Carson & Fitzsimmons				
	410 Carson	Geologic formations and structure of Colo. Springs	1:24,000	Grose	Rocky Mtn. Assoc. Geologists, Geol Soc. Am.
	750 Carson	Geologic map of Pueblo 1° × 2° quadrangle	1:187,500	Scott	U.S.G.S. Misc Field Studies MF-775
	130 Carson	Temp & heat flow in a well near Colo. Springs	1:250,000	Birch	Am Jour Sci
	93 Carson	Description of Colo. Springs quadrangle.	1:48,000	Finlay	U.S.G.S. Atlas Folio 203
	363 Carson	Reconnaissance geol. map of Colo. Springs & vicinity.	1:62,500	Scott	U.S.G.S. Misc Field Studies MF-482
	363 Fitzsimmons	None			
HI	Ft. Shafter				
	5	Geologic map & guide of island of Oahu	1:62,500	Stearns	Hawaii Div Hydrography Bull.
	1	Pyroclastic Geology of Oahu	1:210,000	Wentworth	Bernice P. Bishop Mus. Bull
	15	Honolulu Series, Oahu, Hawaii	1:150,000	Winchell	Geol. Soc. America Bull.
IL	Ft. Sheridan				
	117	Geology for planning in Lake County	1:63,360	Larsen	Illinois Geol Survey Circ. 481

State	Installation	Description	Scale	Author	Publisher
IN	Ft. Ben Harrison				
	31	Ground water resources of Indianapolis area	1:250,000	McGuinness	Indiana Dept. Conserv., Div. Geology
	32	Pages from the geologic past of Marion Cty.	1:70,000	Harrison	Indiana Geol. Survey Circ.
KS	Leavenworth, Riley				
	10 Leavenworth	Description of Leavenworth-Smithville Quadrangle	1:62,500	Hinds	U.S.G.S. Geol. Atlas, Folio 206
	46 Riley	Geol. constr. mat. resources in Riley County	1:31,680	Modge	U.S.G.S. open file report
	30 Riley	Geology of Riley & Geary Counties	1:125,000	Jewett	Kansas Geol. Survey Bull.
	61 Riley	Environment of Camp Funston	1:78,125	Moore	Kansas Geol. Survey Bull.
KY	Campbell, Knox	N/A			
LA	Ft. Polk				
	17	Geology of Vernon Parish	1:62,500	Welch	Louisiana Dept. Conserv. Geol. Survey, Geol. Bull.
	35	Water Resources of Vernon Parish	1:125,000	Rogers	Louisiana Geol. Survey, Water Resources Bull.
MD	Aberdeen, Meade	N/A			
MA	Ft. Devens	N/A			
MO	Ft. Leonard Wood	N/A			
NJ	Ft. Dix	Pre-quaternary geology of New Egypt Quadrangle	1:24,000	Minard	U.S.G.S. Quad. Map
NY	Ft. Drum				
	19	Report of general & economic geology of four townships in St. Lawrence & Jefferson Counties	1:187,000	Smith	NY State Geol. 13th Annual Rept.
NC	Ft. Bragg	None			
OK	Ft. Sill	N/A			
SC	Ft. Jackson				
	22	Geology of Ft. Jackson N. Quadrangle	1:24,000	Pooser	S. Carolina Div Geol Map Sec MS-3
TN	Ft. Campbell	N/A			

State	Installation	Description	Scale	Author	Publisher
TX	Bliss, Hood, Houston	N/A			
UT	Ft. Douglas	N/A			
VA	Belvoir, Eustis, Hill, Lee, Monroe, Pickett				
	56 Belvoir	Bedrock map of Annandale Quadrangle	1:24,000	Huftman	U.S.G.S. open file map
	57 Belvoir	Preliminary surface materials map of Annandale	1:24,000	Force	U.S.G.S. open file map
	221 Belvoir	Preliminary geol. map of Annandale Quad.	1:24,000	Huffman	U.S.G.S. open file map
	Hill	None			
	185 Eustis	Geology of Yorktown & Poquoson Quads.	1:24,000	Johnson	Virg. Div. Mineral Resources Dept.
	Lee	None			
	Monroe	None			
	Pickett	None			
WI	Ft. McCoy	N/A			
WA	Lewis, Yakima Firing	N/A			

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Dugway, UT 84022
USACC
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ATTN: Environmental Office
APO San Francisco, CA 96343

Commander
HQDA, Eighth US Army
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Fort Bragg
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Fort Bragg, NC 28307

HQ, 7th Army Training Command
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APO New York 09114

Commander
HQ USAEREUR and 7th Army
ODCS/Engineer
ATTN: AEAEN-EH (4)
APO New York 09403

Commander
7th Army Combined Arms Training
Center
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APO New York 09168

Commander
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Activity, Europe
ATTN: AEUES-RP
APO New York 09403

Long Beach Naval Shipyard
LT Neil B. Hall, USNR/Code 403
Long Beach, CA 90822

Goran, William D
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